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VOL. CXVII.—No. 3051.] *LONDON: FRIDAY, JUNE 20, 1924.* [*Registered at the General Post Office as a Newspaper.*] [PRICE ... 1s. BY FOREIGN POST 1s. 4d.

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See Advertisement page 34.
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See Advertisements, pages 35 and 65.

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FEED WATER HEATERS, CALORIFIERS, EVAPORATORS, CONDENSERS, AIR HEATERS, STEAM and GAS KETTLES, Merrill's Patent TWIN STRAINERS for Pump Suctions. } ROW'S PATENTS.
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High-class GUNMETAL STEAM FITTINGS.
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Tubes AND Fittings AND Steel Plates.
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See Advertisement, page 27. 1872

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One Superior 400 Kw. Howden - Siemens ELECTRIC GENERATING SET, 250 volts D.C., 350 r.p.m., 155 lbs. pressure.
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In new condition and all seen here at Glasgow.
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The whole of the MACHINERY, TOOLS, PLANT, Etc., of GOVAN ENGINE WORKS (lately belonging to Messrs. DUNSMUIR & JACKSON, Limited,)
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For particulars apply 180, Hope Street, Glasgow.
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Technical Translations from or into Spanish, Italian, French, German, Russian, &c., by experts.—VICTORIA TRANSLATION BUREAU, 21a, Southampton Bldgs., Chancery Lane, W.C. 2.

YARROW & CO. (1922), LTD., GLASGOW.
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See Advertisement page 64, June 13. 2402

Iron Castings up to
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COCHRAN & CO., Annan, LTD., Annan, Scotland. 2106

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See our Illustrated Advertisement, June 6.

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LIMITED,
STATIONARY, STEAM AND MARINE ENGINEERS.
NEWBURY, ENGLAND. 1831

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54 & 55, FETTER LANE, LONDON, E.C.4,
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and Principal Provincial Cities and Abroad.

Diesel Engines, 300, 530, 800,
1200 and 1750 B.HP., M.A.N., with or without dynamos; condition as new. About one-third market price; seen London. For all spares above sizes in stock.
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Sizes 1½ B.HP. and upwards.
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See advertisement alternate weeks. 9335

Centrifugals.
Pott, Cassels & Williamson,
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1676
See half-page Advertisement, page 61, June 6.

The Manchester Steam Users' ASSOCIATION.

For the prevention of Steam Boiler Explosions and for the attainment of Economy in the Application of Steam. 9, MOUNT STREET, MANCHESTER.

Chief Engineer: C. E. STROMEYER, M.I.C.E.

Founded 1854 by Sir WILLIAM FAIRBAIRN.

Certificates of Safety issued under the Factory and Workshops Act, 1901. Compensation for Damages and Liabilities paid in case of Explosions. Engines and Boilers inspected during construction. 2005

The Institution of Structural ENGINEERS.

EXAMINATIONS FOR GRADUATESHIP AND ASSOCIATE-MEMBERSHIP.

The next Examinations for Graduateship and Associate-Membership of the Institution will be held in London, Salford (Manchester), and such other centres as may be arranged, on Wednesday, Thursday and Friday, the 2nd, 3rd and 4th July.

The closing date for entries is Wednesday, the 25th June. A Syllabus and Entry Form may be obtained from the SECRETARY of the Institution of Structural Engineers, 231, Abbey House, Westminster, S.W.1. F 82

Correspondence Courses for

Inst.C.E., Inst.Mech.E., London Univ. (Matric., Inter., B.Sc.), and All ENGINEERING EXAMINATIONS personally conducted by Mr. TREVOR W. PHILLIPS, B.Sc. (Honours), Assoc. M.Inst.C.E., M.R.S.I., F.R.S.A., etc. Also Day Tuition in Office. Excellent results at all Exams. Courses may commence at any time, and all Students receive individual tuition.—For full particulars apply to 8/11, TRAFFORD CHAMBERS, 58, SOUTH JOHN STREET, LIVERPOOL. 1993

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T. G. Howes Thomas, (Inst.

C.E. Coach, late of Westminster), Consulting Engineer, has resumed his "Up-to date" Coaching by correspondence, and is prepared to advise on proposed or accepted patents.

34, Baldwin Street, Bristol. D 847

TENDERS.

STATE ELECTRICITY COMMISSION OF VICTORIA,
Melbourne,
Victoria,
AUSTRALIA.

Tenders are Hereby

Invited for the SUPPLY, DELIVERY, etc., of the following for the Morwell Power Scheme.

Copies of Tender Form and Specification will be available upon application to:—

AGENT GENERAL FOR VICTORIA,
Melbourne Place, Strand,
London, W.C.2.

SPECIFICATION No. 24/38—
BUSHING INSULATORS
FOR 6600 V. TRIFURCATING BOXES.

CHARGE:—£2 2s. for the first three copies of Tender Form, Conditions of Contract and Specification complete. This charge will be returned on receipt of a *bona fide* Tender. A fourth copy and any further copies will be supplied for the sum of 10s. 6d. each. This charge is not returnable.

PRELIMINARY DEPOSIT:—A Preliminary Deposit of £10 is to be lodged with Tender.

The Specification may be inspected at the above-mentioned office.

The Commission does not bind itself to accept the lowest or any Tender.

Tenders on prescribed form, properly endorsed and addressed, must be delivered to the undersigned in Melbourne, not later than Five p.m., 15th September, 1924.

R. LIDDELOW,
Secretary. D 956

METROPOLITAN WATER BOARD.

MAIN, CRICKLEWOOD TO MARBLE ARCH.

TENDERS FOR THE LAYING AND JOINTING OF 42 INCH AND 36 INCH DIAMETER CAST IRON MAINS BETWEEN CRICKLEWOOD AND MARBLE ARCH.

The Metropolitan Water Board invite

Tenders for Laying of 42 in.

and 36 in. internal diameter WATER MAINS from the Board's works at Cricklewood in the Parish of Willesden, to Seymour Street in the Parish of St. Marylebone, together with contingent Works.

Drawings, Conditions of Contract, and Specification may be inspected without payment of fee at the Offices of the Board, Chief Engineer's Department (Room 201), on and after 16th June, 1924.

Form of Tender, Conditions of Contract, and Specification, Bills of Quantities, and Schedules of Prices, together with drawings and a spare copy of the Bills of Quantities and Schedules of Prices, may be obtained on and after 19th June, 1924, from Mr. HENRY B. STILGOE, M.Inst.C.E., the Chief Engineer, on production of an official receipt for the sum of £20, which sum must be deposited with the Accountant to the Board, and will be returned on receipt of a *bona fide* Tender, accompanied by all the above-named documents and drawings (with the exception of the spare copy of the Bills of Quantities and Schedules of Prices, which may be retained by the Tenderer). Such payments and applications must be made between the hours of Ten a.m. and 4.30 p.m. (Saturdays Ten a.m. and Twelve noon). Cheques must be made payable to the "Metropolitan Water Board" and not to individuals.

Tenders, enclosed in sealed envelopes, addressed to "The Clerk of the Board, Metropolitan Water Board, New River Head, Clerkenwell, E.C.1, and endorsed "Tender for Mainlaying, Cricklewood to Marble Arch," must be delivered at the Offices of the Board (Room 123) not later than Ten a.m. on Monday, 7th July, 1924.

The Board do not bind themselves to accept the lowest or any Tender.

C. F. STRINGER,
Clerk of the Board.

Offices of the Board,
New River Head,
Clerkenwell, E.C.1.
10th June, 1924. F 6

CORPORATION OF GLASGOW.

SEWAGE DEPARTMENT.

CONSTRUCTION OF SLUDGE STEAMER.

The Corporation invite

Tenders from Shipbuilders

for the CONSTRUCTION of a SLUDGE STEAMER, to conform to Specification, Drawings and Form of Tender, which can be obtained on application to the General Manager of the Sewage Department, 50, John Street, Glasgow, on payment of a fee of Five Guineas, which will be refunded to each applicant who sends in a *bona fide* Tender. Sealed offers marked outside "Tender for Construction of Sludge Steamer," must be lodged with the subscriber not later than Wednesday, 16th July, 1924.

J. LINDSAY,
Town Clerk.

City Chambers, Glasgow.
17th June, 1924. F 75

CORPORATION OF THE CITY OF AUCKLAND, NEW ZEALAND.

QUARRY PLANT.

MOTORS, CRUSHERS, etc.

The above Corporation invite

Tenders for the Supply

of PORTION or the whole of the following PLANT:—

(1) A Large Jaw Crusher, capable of dealing with 1½ cwts. spawls (columnar basalt) and reducing same to 5 inches and less, at the rate of 250 cubic yards per day of eight hours.
(2) Two Jaw Crushers, each capable of reducing 125 cubic yards of 5 inch spawls to 2½ inch and less, per day of 8 hours.
(3) One or two Disc Crushers, capable of dealing with 120 cubic yards of 2 to 4 inch spawls, and reducing same to ¾ inch and less, per day of eight hours.
(4) One belt-driven Air Compressor, capable of supplying 200 cubic feet of free air (working pressure 100 lbs. per square inch).
(5) Five three-phase Electric Motors, 400 volts, 50 cycles, on adjustable rail beds to drive the above.

Specifications and full particulars may be seen at Room 40, New Zealand Government Office, 415, Strand, W.C. 2, on and after Monday, June 23rd, and, for the purpose of supplying information, the Assistant City Engineer of Auckland may be consulted at the above Office between the hours of Eleven a.m. and One p.m., on Monday, June 30th, Tuesday and Wednesday, July 1st and 2nd.

Sealed Tenders, endorsed "Tenders for Crusher Plant," to be addressed to:—

Mr. JAMES TYLER,
c/o New Zealand Government Office,
415, Strand, London, W.C.2,

not later than Twelve Noon, Thursday, July 10th, 1924.

The Corporation reserves the right to accept a Tender for the whole or portion of the plant quoted for, and it does not bind itself to accept the lowest or any Tender.

(Sgd.) J. TYLER,
Assistant City Engineer.

Office of the High Commissioner
for New Zealand,
415, Strand,
London, W.C. 2.
June 14th, 1924. F 59

IN THE HIGH COURT OF JUSTICE (Companies Winding Up).

To be Offered For Sale by

TENDER, pursuant to a Order of the Registrar Companies (Winding Up) made in the matter of ALLEN & SIMMONDS (READING), LTD., Branch Nominees Ltd., *v.* Allen & Simmonds (Reading), Ltd., 1923, A. No. 2686, either in One Lot as a Going Concern, or in the following Lots:—

LOT 1.

(A) A FREEHOLD GARAGE, SHOWROOMS AND OFFICES situate in the centre of READING, with frontages to Friar Street and Station Road, and containing an area of about 23,000 square feet, together with the Assets and the Business carried on on such premises, and the whole of the Share Capital and Debentures in Great Western Motors Ltd.

(B) A block of TEN FREEHOLD COTTAGES adjoining the above.

(C) A FREEHOLD FACTORY at Vastern Road, READING, with Modern Buildings thereon, covering an area of about 14,500 square feet, at present let as a Motor Body Building Works, in connection with the aforesaid business.

LOT 2.

(A) A LEASEHOLD ENGINEERING WORKS, at READING containing a total floor space of about 27,000 square feet, held for an unexpired term of 67 years at Ground Rents amounting to £77 6s. per annum. These Works are equipped with high-class ENGINEERS' MACHINE TOOLS for the manufacture of Piston Rings and other Specialities of the Company.

(B) THIRTY LEASEHOLD COTTAGES and a RESIDENCE adjoining held for a similar period at nominal ground rents.

(C) LEASEHOLD PREMISES suitable for GARAGES, situate No. 107, Caversham Road, READING, held for an unexpired term of 61 years.

(D) A FREEHOLD PROPERTY on the THAMES, at CAVERSHAM, adjoining the Bridge, formerly a Club, but now let off in self-contained Flats.

(E) A FREEHOLD HOUSE, No. 18, King's Meadow Road, READING.

(F) THE GOODWILL OF THE BUSINESS of ALLEN & SIMMONDS (READING), LTD., as a Going Concern, and LETTERS PATENT for Improvements in the manufacture of Piston Rings, etc.

LOT 3.

3,000 £1 fully-paid Shares, Great Western Hotel (Reading), Ltd.

25 £1 fully-paid Deferred Ordinary Shares, and 5,500 £1 fully-paid Participating Preferred Ordinary Shares in the Reading Foundry Co., Ltd.

Tenders, which must be on the form contained in the Particulars, are to be sent to the Registrar, Companies (Winding Up), Room 48, Bankruptcy Buildings, Carey Street, W.C.1, and marked "Tender re Allen & Simmonds (Reading), Ltd.," and delivered under seal by TWELVE NOON, on or before SATURDAY, 28th July, 1924. Particulars, with Plan, Form of Tender and Conditions of Sale, may be had of Messrs. W. B. PEAT & CO., Chartered Accountants, 11, Ironmonger Lane, London, E.C.2, Messrs. WILDE, WIGSTON & SAPTE, Solicitors, 21, College Hill, London, E.C.4; and of Messrs. PEACOCK & GODDARD, of 3, South Square, Gray's Inn, London, W.C.1. F 32

BOMBAY, BARODA & CENTRAL INDIA RAILWAY.

The Directors are prepared to receive up to Noon on Wednesday, 9th July

Tenders for the Supply of:—

GIRDER BRIDGES (100 ft. Spans).

Tenders must be made on forms, copies of which, with Specification, can be obtained at these Offices on payment of 20s. each (which will not be returned).

The Directors do not bind themselves to accept the lowest or any Tender.

S. G. S. YOUNG,
Secretary.

Offices: 91, Petty France,
Westminster, S.W.1.
16th June, 1924. F 62

COUNTY OF LONDON.

The London County Council invites

Tenders for the Removal and

DISPOSAL of ASHES, by barge, from the Council's power station at East Greenwich, for alternative periods of six and twelve calendar months, commencing on 1st August, 1924.

Particulars and forms of Tender may be obtained from the General Manager, Tramway Offices, Victoria Embankment, W.C.2.

No Tender will be considered if received by the Clerk of the Council at the County Hall, Westminster Bridge, S.E.1, after Four p.m. on Monday, 7th July, 1924.

The Council does not bind itself to accept the lowest or any Tender.

JAMES BIRD,
Clerk of the London County Council. F 81

LOCHABER WATER POWER.

CONTRACT NO. 1.

THE BRITISH ALUMINIUM COMPANY LIMITED is prepared to receive

Tenders for the Construction

of a REINFORCED CONCRETE PIER and APPROACH, VIADUCT and WORKS connected therewith, at Fort William, Inverness-shire.

Persons desiring to tender may obtain, on and after the 23rd June, 1924, from the Company's Engineers, Messrs. C. S. MEIK & BUCHANAN, 16, Victoria Street, Westminster, S.W.1, copies of the drawings, specification, form of tender, etc., upon payment of £5 (by cheque), which will be returned upon receipt of a *bona fide* Tender together with the drawings supplied.

Preference will be given to Contractors on the King's Roll and who are prepared to employ 75% of ex-service men.

Sealed Tenders endorsed "Lochaber Water Power Contract No. 1," addressed to the SECRETARY, 109, Queen Victoria Street, E.C.4, must be received before Ten a.m. on Monday, 21st July, 1924.

The Company does not bind itself to accept the lowest or any Tender.

G. W. JEFFERY,
Secretary. F 80

WESTERN AUSTRALIAN GOVERNMENT.

ELECTRICITY SUPPLY.

POWER STATION PLANT.

The Government of Western Australia is prepared to receive

Tenders for the Supply

and DELIVERY, C.I.F. Freemantle, including erection, of the following:—

One 12,500 Kw. TURBO-ALTERNATOR, complete with Surface Condensing Plant.
WATER TUBE BOILERS, ECONOMISER, FANS, CHIMNEY, etc., also COAL and ASH PLANT.

The Government does not bind itself to accept the lowest or any Tender.

Sealed Tenders to be endorsed "Tender for Power Station Plant," and to be lodged with the AGENT GENERAL FOR WESTERN AUSTRALIA, Savoy House, Strand, London, W.C.2, not later than Noon on Friday, August 15th, 1924.

Copies of Forms of Tender and Specifications will be available on and after the 23rd June, 1924, on application to the Agent General for Western Australia as above.

A charge of £1 will be made for the first two copies of each Specification, additional copies being obtainable at 10s. each. These charges will not be returnable in any circumstances whatever.

Any further information can be obtained by applying to the General Manager and Engineer of the Western Australian Government Electricity Supply, Mr. WILLIAM H. TAYLOR, at the above address on and after the 23rd June, 1924. F 61

ABERDEEN CORPORATION WATER WORKS.

EXTENSIONS 1920.

CONTRACT NO. 20.

AIRY HALL SERVICE RESERVOIR.

The Town Council of Aberdeen are prepared to receive

Tenders from Competent

Persons willing to enter into a Contract for the CONSTRUCTION of a CONCRETE COVERED SERVICE RESERVOIR of a capacity of 7 million gallons, at Airy Hall, near Aberdeen.

The Drawings may be inspected and Specification, Schedule of Quantities, and Form of Tender obtained, on and after 27th June, 1924, on application at the Water Engineer's Office, 41½, Union Street, Aberdeen. Early application is desirable, and no specification will be given out after 5th July.

For each Specification a deposit of Five Pounds Sterling will be required, which sum will, after a Tender has been accepted, be returned to the Tenderer, provided that he shall have sent in a *bona-fide* Tender, based on the drawings, specification and schedule of quantities provided, with the schedule of quantities fully priced out in detail, and shall not have withdrawn the same.

The employment of labour shall be in accordance with the revised conditions of the Unemployment Grants Committee.

Tenders on the Forms prescribed and enclosed in securely sealed envelopes, endorsed "Tender for AIRY HALL RESERVOIR," are to be addressed to the undersigned. No Tender delivered after Noon on 16th July, 1924, will be considered.

The Town Council do not bind themselves to accept the lowest or any Tender.

GEORGE MITCHELL, M.Inst.C.E., F.C.S.
Water Engineer's Office,
41½, Union Street, Aberdeen.
17th June, 1924. F 74

THE SOUTH INDIAN RAILWAY COMPANY, LIMITED, are prepared to receive

Tenders for the Supply of:—

POINTS AND CROSSINGS.

Specifications and Forms of Tender will be available at the Company's Offices, 91, Petty France, Westminster, S.W.1.

Tenders, addressed to the Chairman and Directors of the South Indian Railway Company, Limited, marked "Tender for Points and Crossings," must be left with the undersigned not later than Twelve Noon on Friday, the 4th July, 1924.

The Directors do not bind themselves to accept the lowest or any Tender.

A charge, which will not be returned, will be made of £1 for each copy of the Specification.

Copies of the drawings may be obtained at the Offices of the Consulting Engineers to the Company, Messrs. ROBERT WHITE & PARTNERS, 3, Victoria Street, Westminster, S.W.1.

A. MUIRHEAD,
Managing Director.

91, Petty France, S.W.1.
17th June, 1924. F 83

THE GREAT INDIAN PENINSULA RAILWAY COMPANY, 48, Copthall Avenue, London, E.C.2, invite

Tenders for:—

1.	MILD STEEL BARS	Fee	2/6
2.	WICKS	,,	2/6
3.	SEAMING CORD, &c.	,,	2/6
4.	HELICAL SPRINGS	,,	5/-
5.	GALVANISED WROUGHT IRON WATER TUBES, &c.	,,	7/6

Tenders are due by Eleven a.m. on 1st July, 1924. Tender forms obtainable at above address. Fees not returnable. F 86

KINGSBRIDGE TERMINUS.

17th June, 1924.

THE DIRECTORS OF THE GREAT SOUTHERN AND WESTERN RAILWAY are prepared to receive

Tenders for the Reconstruction

of the DESTROYED PORTION of the ROAD BRIDGE over the River Sulr, at Fiddown.

Copies of the specification and drawings can be obtained on and after 25th inst. from the Company's Chief Engineer, Inchicore, Dublin, on payment of a fee of One Guinea, which will be returned on receipt of a *bona fide* Tender, accompanied by the drawings and specification.

Tenders should be posted so as to reach the undersigned not later than TEN a.m. on July 15th, and should be enclosed in sealed envelopes endorsed "TENDER FOR FIDDOWN BRIDGE."

The Directors do not bind themselves to accept the lowest or any Tender.

C. E. RILEY,
Secretary. F 90

UNIVERSITY COLLEGE, GOWER ST., W.C.

Tenders are Required for

CARRYING OUT the EXTENSIONS of the EXISTING HEATING APPARATUS in the South wing of the College buildings, according to detailed designs and Specifications prepared by me.

Firms desiring to Tender will be requested to deposit in my hands the sum of five guineas for copies of the Specification, Conditions of Contract, plans and drawings, of which four guineas will be returned on the return of the documents with a *bona fide* Tender for the work.

The appropriate cubical contents of the buildings to be heated is 600,000 cubic feet.

Permission to inspect the premises can be obtained on application to the Secretary of the College.

All applications with remittances must be in my hands by Monday morning, July 1st. The Tenders must be sent in by Thursday, July 10th, and the work is to be completed by September 15th.

ARTHUR H. BARKER, B.Sc., B.A., Wh.Sc.
Consulting Engineer,
100, Victoria Street, S.W.1. F 87

APPOINTMENTS OPEN.

COUNTY BOROUGH OF BELFAST.

MUNICIPAL COLLEGE OF TECHNOLOGY.
Principal; JOHN EARLS, B.A.

The Belfast Education Committee invite

Applications for the Position

of PROFESSOR of PHYSICS and ELECTRICAL ENGINEERING at the Municipal College of Technology, Belfast.

The salary attached to the position is £600 per annum, rising by annual increments of £25 to a maximum of £750 per annum.

Particulars of the Duties and Conditions of Appointment may be obtained from the undersigned, with whom applications, on the special Form provided for the purpose, must be lodged not later than Saturday, 5th July, 1924.

The duties of the position commence on the 1st September next.

Applications should be accompanied by copies of three recent testimonials. (Original testimonials must not be sent.)

The appointment will be subject to the condition laid down by the Ministry of Home Affairs, copy of which may be had on application.

CANVASSING IS STRICTLY FORBIDDEN AND WILL DISQUALIFY.

RUPERT STANLEY,
Director of Education. F 57

COUNTY BOROUGH OF BARNSLEY EDUCATION COMMITTEE.

TECHNICAL AND MINING SCHOOL.

PRINCIPAL:—D. PATON GRUBB, A.R.S.M., M.ENG., ETC.

APPOINTMENT OF FULL-TIME TEACHER IN ELECTRICAL ENGINEERING.

The Higher Education Committee invite

Applications from Fully

qualified persons for the POSITION of FULL-TIME TEACHER in Electrical Engineering Subjects.

Degree or its equivalent and practical experience essential. Salary in accordance with Burnham Scale for Technical Teachers, less usual deductions.

Full particulars regarding the position may be had upon application, to the Principal.

H. DAVIES,
Director of Education. F 73

LITERATURE.

The Control of the Speed and Power Factor of Induction Motors. By MILES WALKER, M.A., D.Sc., Professor of Electrical Engineering in the University of Manchester. London: Ernest Benn, Limited. [Price 18*s.* 6*d.* net.]

THE development of power supply has for many years shown a marked tendency towards the use of alternating current distribution, as this form of electrical energy has many advantages and only two drawbacks, compared with direct current. In the first place, the standard alternating current motor is essentially a constant speed motor, speed regulation offering various difficulties, and, secondly, the excitation of the motor has to be supplied from the power station in the form of wattless currents which are an undesirable burden, both on the generating station and on the cable system. These two disadvantages have for a long time occupied the minds of electrical engineers, many papers have been read and many articles have been written on this subject, whilst an unending variety of patents have been taken out to overcome the two difficulties in question.

The book of Professor Miles Walker on "The Control of the Speed and Power Factor of Induction Motors" fills a decided gap in our literature by collecting and co-ordinating the whole available material concerning this subject. That this has never been attempted before is partly explained by the fact that the development of methods for the speed control of induction motors has only, in recent years, made real headway; also it may be due to the difficulties of the subject matter itself.

Professor Miles Walker gives us a survey of the various means of speed regulation and power factor correction now at our disposal, and a study of the book is to be recommended not only to students and designing engineers in particular, but, in addition, to all engineers engaged in connection with the supply, distribution and use of electric power. Such readers will find in it descriptions of regulating methods based on fundamental principles and set out in clear terms, which afford an opportunity of becoming acquainted with the principal features of the various devices and will enable them to decide which of the methods described will best meet their particular requirements.

Practical engineers should not be discouraged from perusing the book by the fact that the first two chapters are rather theoretical and purely mathematical. The rest of the book can be followed without going through these mathematical fundamentals. We are given there the principles of inversion, the development and the geometry of the circle diagram of the induction motor and the deduction of the characteristics of this motor from the circle diagram. Professor Miles Walker was presumably induced to start with these fundamentals by the desire to make the volume a text-book for students, and there is no doubt that he has a particular talent for treating his subjects from this point of view. He tells all that is necessary to give a grasp of the problem involved and its solution, leaving at the same time certain aspects of the matter under consideration to be followed out more in detail by the reader.

The basis and development of the circle diagram and the explanation of the methods of inversion have probably never been given in so simple, clear and concise a form in any previous book of reference. Still it is debatable whether this part would not have been better placed at the end of the volume in the form of an appendix, as the rest of the book can be understood and explained quite well without these mathematical derivations.

Beginning with Chapter III, the reader is introduced into the heart of the subject and given immediately a complete schedule of all methods of speed control, which are available at present. The author then explains in detail the principle and describes the working of the various methods and the ideas on which they are based; starting with rheostatic control in the rotor circuit with particular reference to its application to rolling mill motors and winding gear drives. We cannot quite agree that the most satisfactory control for flywheel sets used in connection with such plants is a liquid controller worked by a torque motor. This apparatus has the inherent drawback of the liquid type of rheostat of using a liquid, which can evaporate or disintegrate and corrode the metal parts of the apparatus. Modern contactors have proved in practice to be most satisfactory and the contactor type regulator described in the same chapter, which is now often used in place of the liquid slip-regulator, apart from the fact that it avoids the use of liquids, is quicker in action and if anything more reliable in service.

The author interrupts these descriptions, which are of general interest, by inserting a rather special subject, that of ship propulsion by induction motors, giving at the same time the mathematical treatment of this problem. Again one cannot help feeling that the latter would have been put with advantage at the end of the book as an example of the application of the methods of inversion, as this particular field has quite peculiar aspects, which are not of general interest and only concern a few specialists in the subject.

In the next chapter we find the various kinds of pole-changing devices described. The winding and controller diagrams and the photographs of the operating gear required for this kind of speed regulation make it appear that the gear is bigger and more complicated than the motors, and suggest that this solution of the problem introduces too many complications to be a satisfactory solution, except in cases where only two or at most four speeds are required which must, moreover, have definite ratios as 1 : 2 or 2 : 3. The field of application of this form of speed regulation is therefore necessarily limited.

The solutions of the problem by Hunt and Creedy, which are then explained, are a distinct advance on these cruder methods, although also requiring some rather elaborate and complicated auxiliary gear. The number of steps which can be obtained with these arrangements is also limited, although the Creedy motor can be built for a larger number of steps than any of the other pole-changing machines. The clear and simple explanation of the principle of the Hunt and Creedy motors will be particularly welcome to many engineers who have in the past found this subject difficult to follow.

The rest of the book is taken up by the most comprehensive exposition yet published of speed control and power factor correction by use of commutating devices, such as phase converters, three-phase commutator motors, Leblanc exciters and various phase advancers, notably that introduced by the late Professor Kapp. We find descriptions of the various methods in use to control the speed of induction motors which are driving rolling mills, a very clear explanation of the ohmic drop exciter, which has to be used in connection with some of these methods, and a comparison of the performance of an induction motor when provided with an alternating current exciter and when provided with a direct current exciter. These subjects are of growing importance and the various methods which are described offer advantages compared with all other arrangements for speed control, more particularly those based on changing the number of poles, which make it certain that this form of control will be developed and used more and more, apart from the still greater field for appliances for power factor correction. From this point of view we could have wished for more details in these last chapters, which are rather brief in comparison with the number of examples, pictures and full descriptions and diagrams given in the chapters on pole-changing control. Even so, Professor Miles Walker succeeds in giving in a comparatively small space an almost complete survey of this most interesting and important subject, and shows his wonderful gift for presenting and explaining most complicated and intricate problems so simply and clearly that everybody can grasp his explanations.

These remarks also apply to the more mathematical parts of the book and the various diagrams, where the precise meaning of each item is clearly set out as regards quantity, sense and direction. This simple feature is often omitted in technical books, with the result that difficulties arise and mistakes are made, whenever readers try to apply the diagrams to a case occurring in actual practice.

We have no doubt that the book will see many future editions, and for this reason we venture to suggest that fuller explanations may be given on a few subjects. The treatment of rolling mill and winding gear drives in Chapter III is rather sketchy. People who have studied the subject already will not find anything new in it, while anybody not conversant with this matter will hardly be able to follow it all. Further in case of motors arranged for running at several speeds with pole-changing control, the amount of torque required at each speed has a very important bearing on the selection of this kind of control and of the particular winding. This point should have deserved greater consideration. To give the percentage torque or horse-power available for each winding combination would not take much room and add considerably to the value of the description for engineers, who wish to use this method of speed regulation. If necessary some of the examples given under this head might be omitted so as to make room for such additions.

The printing and the illustrations of the book are excellent. The headlines of the various chapters could with advantage be set out more distinctly, so as to define clearly the beginning of each main section and thus help readers to find quickly any particular point on which they desire enlightenment.

Engineers will find in the volume a great amount of most valuable information for which previously considerable searching in engineering literature was necessary, condensed and clearly set out in commendably few words. Apart from this the author has drawn upon his own great store of knowledge and experience whenever he found this expedient or necessary, thus giving a well-thought-out and complete exposition of the whole subject.

BRITISH EMPIRE EXHIBITION; WATERWORKS APPLIANCES—I.

WATERWORKS appliances are decidedly restricted in quantity at the British Empire Exhibition, although several firms show these to some extent as side lines. The most important exhibit of Messrs. Beck and Co., Ltd., 130, Gt. Suffolk-street, Southwark, S.E.1, is their well-known Imperial positive water meter, which has been in use for many years and is probably familiar to most of our readers. The water meters are shown with the top cover removed, so that the action of the internal mechanism can be observed, and similar meters adopted for measuring light and heavy oils are also on view. Messrs. Beck are also exhibiting a simple and convenient appliance, recently introduced by them for tapping gas and water mains under pressure. This appliance is illustrated in Figs. 1, 2 and 3 on page 784. This consists essentially of a large plug cock, constructed of gunmetal and mounted on a cast-iron saddle, which can be clamped to the main, as shown. A tight joint between the saddle and the main is secured by means of a rubber ring. With the plug turned so as to close the opening to the main, a combined drill and tap is first inserted horizontally through a slot in the body and passed through a packed gland in the plug, so that the working portion of the tool is completely surrounded by the plug. The latter is then turned through an angle of 90 deg., to bring the axis of the tool into the vertical plane, when the tool can be pressed down into contact with the main, and the hole drilled and tapped by means of a ratchet brace. After this has been done, the tool is withdrawn and removed by a series of operations carried out in the reverse order to that described above, the tool then being replaced by another carrying a stop ferrule, as shown in Fig. 3. When the ferrule has been screwed into the tapped hole previously formed, by a series of operations similar to those employed for the drilling and tapping process, the whole appliance can be removed and a service pipe can then be connected up with the ferrule. The operation of drilling and tapping the hole and inserting the ferrule can be carried out in about 10 minutes.

The frequent need for the distant control of sluice valves in various types of installations has led to an increasing use of electrical control for this purpose. In Fig. 4 we illustrate an example of this type of valve, one of which may be seen

WATERWORKS APPLIANCES AT THE BRITISH EMPIRE EXHIBITION.

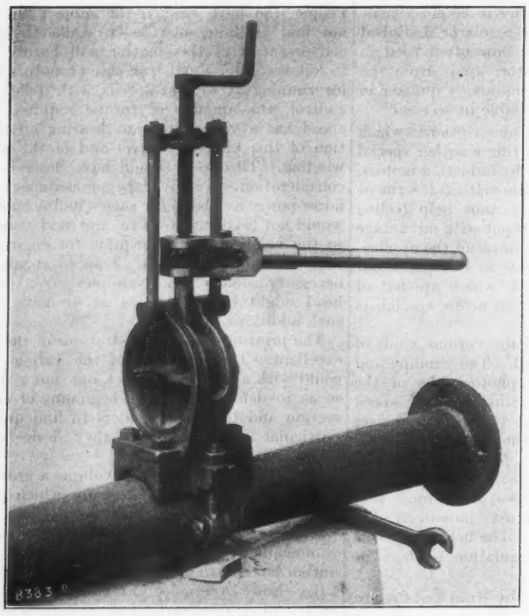
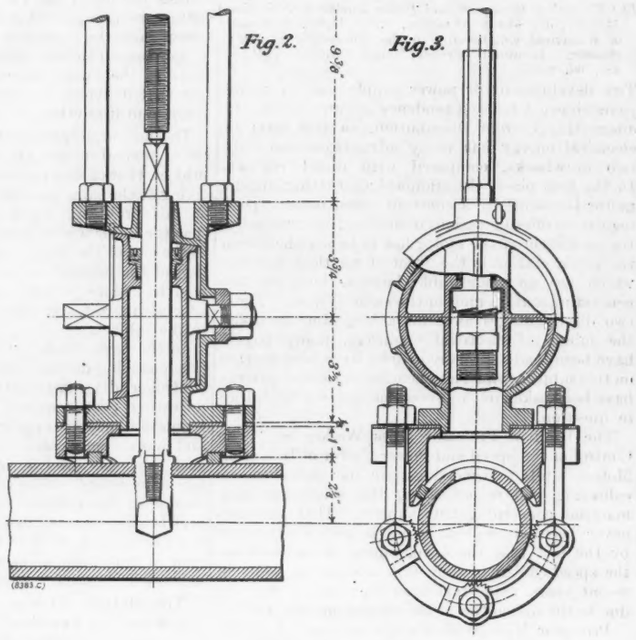


FIG. 1.



FIGS. 1 TO 3. DRILLING AND TAPPING APPLIANCE FOR MAINS UNDER PRESSURE; MESSRS. BECK AND CO., LIMITED.

in operation at the stand of Messrs. Glenfield and Kennedy, Limited, Kilmarnock. The actual valve illustrated is a 50-in. sluice valve made by the firm for Messrs. Associated British Manufacturing (Egypt), Limited, to work under a head of 14 ft., the test pressure being 30 lb., and the valve being operated by a 2-b.h.p. reversing motor, running at 1,000 r.p.m. on d.c. 100-volt supply. Among other valves of the same type we may mention that this firm has supplied two 14-in., five 18-in., two 20-in., nine 27-in. and six 30-in. valves for the Mullick Ghat Pumping Station for the Calcutta Water Supply, to which we referred on page 689 *ante*, when dealing with the pumps for this station constructed by Messrs. Mather and Platt, Limited. As will be seen from Fig. 4 annexed, there is bolted to the dome of the valve casing a distance piece and bracket, carrying the motor, which is of the squirrel cage reversible type. The motor spindle extension carries a worm, gearing with a worm wheel housed in the casting surrounding the valve spindle. The latter is screwed and the worm wheel forms a nut on the spindle screw in the ordinary way. The end thrust of the worm is taken by ball bearings. The whole worm gear runs in an enclosed bath of oil, which is dust proof. The worm wheel rim is of phosphor bronze. The upper end of the valve spindle carries a short arm projecting through a vertical graduated slot in the upper casing; this arm indicates the position of the valve. At the same time, it serves to operate the two self-resetting limit switches which cut the motor out automatically on the valve reaching its fully open or completely closed position. The limit switches are worked by short strikers which come in contact with the indicator arm. The valve is controlled by a reversible switch in the power house marked "Open," "Closed" and "Off." In the latter position the motor is completely isolated from the mains. The controller is hand operated for starting either way, but is brought to the "off" position automatically by the action of the limit switches of the valve. The two switches at the valve are used for forward running and reverse, respectively, as will be clear from the foregoing remarks.

Certainly an apparatus which deserves the attention of waterworks engineers is the Peebles washer for dirty filter sand also exhibited by Messrs. Glenfield and Kennedy, Limited. This machine is constructed either in portable or fixed form, both of which are shown in our illustrations, Figs. 5 to 7, page 785. Although not quite the same in detail in the two patterns, the principle is identical and a description followed with the section Fig 7, will convey a good idea of the operation of both types.

Referring then to this figure the features of the machine consist of a series of hoppers, and a series of hydraulic jets. The dirty sand as it comes from filter is fed into a large hopper shown at the left-hand end of the machine. Here it is worked down on to a screen which is hung on spring bars and shaken by a small water motor. By this screen any coarse material is discarded, while the fine sand is washed by a jet of water into a partition below. Here the sand gravitates towards a water-jet, by which it is carried up a curved pipe and discharged into a large hopper above. In this hopper, filled with water, the sand sinks to the bottom, and when it finally reaches the bottom pocket, is shot by another water-jet through a straight tube into the hopper marked No. 1. Here it circulates in the water, finally settling again to the bottom, to be again ejected by water-jet through a tube, now into hopper No. 2. It is transferred automatically subsequently in a similar way into hopper No. 3, and from this, again by water-jet is forced out of the discharge tube, to be deposited on the clean sand platform as shown in Fig. 5. The surplus water finds its way back from hopper No. 3, over the lip of an enclosing casing, into No. 2, and from here back into No. 1. From the latter it flows over a sill and into the large hopper, between two baffle plates, serving in this way to circulate the incoming dirty sand and keeping it over to the left side so as to bring it down properly to the jet below and prevent it escaping direct over a weir referred to later. In this way the cleanest sand at the No. 3 end is in contact only with the cleaner water, the dirtier water accomplishing the preliminary stages of washing the dirty sand. Each jet is provided at the throat of the ejector tube with a set of subsidiary jets fed into the main jet at right angles with the object of agitating the sand as much as possible as it is carried in the water. The preliminary hopper also is provided with an agitating rose jet as shown in Fig. 7. All jets are supplied from a long manifold which forms the backbone of the machine and is coupled by a 4 in. branch to the main, which for the satisfactory use of the machine should give a pressure up to about 5 lb. per square inch. We may draw attention to the bend

FIG. 4. 50-IN. ELECTRICALLY-OPERATED SLUICE VALVE; MESSRS. GLENFIELD AND KENNEDY, LTD.

WATERWORKS APPLIANCES AT THE BRITISH EMPIRE EXHIBITION.

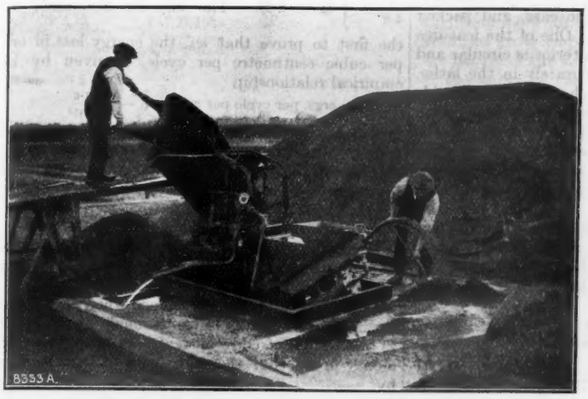


FIG. 5. SAND WASHER IN FIXED SETTING.

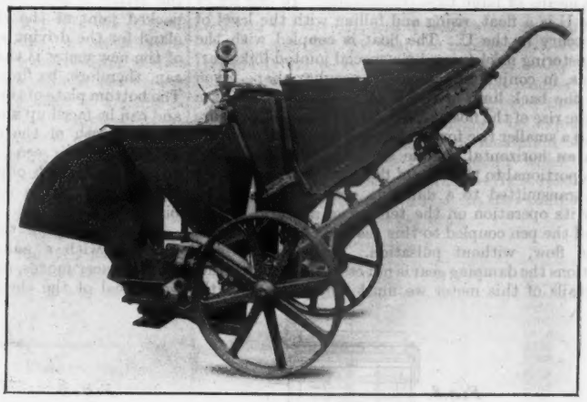
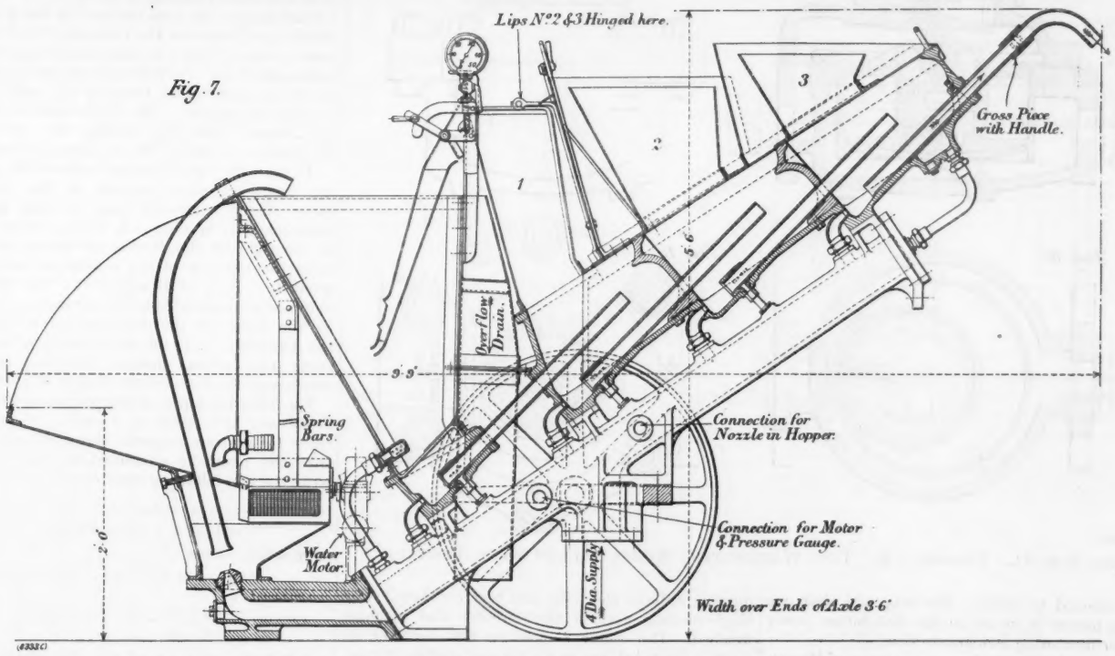


FIG. 6. PORTABLE TYPE OF SAND WASHER.



FIGS. 5 TO 7. PEEBLES SAND-WASHING MACHINES; MESSRS. GLENFIELD AND KENNEDY, LIMITED.

connecting the upper end of the manifold with the No. 3 hopper casing, supplying surplus clean water to flow back as described above. Such surplus leaves the preliminary cleaning hopper by way of a weir below the gauge, and an overflow drain shown in the drawing. The bulk of the dirt is cleared away at once by this drain from the preliminary hopper, being carried upwards by the action of the agitating rose mentioned above.

The machine is very rapid in operation and the process, as may be imagined, is very thorough. With a pressure of 3 lb., the machine will clean a ton of sand in 23·5 minutes, or at the rate of 60 cub. ft. per hour. With 4 lb. of pressure, 82 cub. ft. of sand per hour can be dealt with, and with 5-lb. pressure, the amount handled is 98 cub. ft. per hour. Messrs. Glenfield and Kennedy have for long been well-known makers of sand-washing machines, but they put the Peebles Sand washer forward as capable of dealing with about six times as much material as their former type of machines in a given time. The cost of working is very small, as the water is so effectively utilised, while the whole action is automatic, only one man being required to supply it with the unwashed sand; another is generally employed to stack the cleaned sand. Tests show that at 3-lb. pressure about 2,200 gallons in all are used for washing 1 ton of sand; 1,980 gallons with water at 4-lb. pressure, and 1,925 gallons at 5-lb. pressure.

The Cole recording Pitometer, of the British Pitometer Company, which forms another exhibit at the stand of Messrs. Glenfield and Kennedy, Limited, was briefly described in the paper on "Improvements in Mechanical Contrivances in connection with the Storage and Distribution of Water," read by Mr. E. Bruce Ball at the Glasgow summer meeting of the Institution of Mechanical Engineers last year, and reprinted in our issue of July 13, 1923 (page 64). The instrument consists of a Pitot tube arrangement of two $\frac{1}{4}$-in. tubes contained in a flattened oval rod, ending in two orifices, one of which points up-stream and the other down. The instrument can be inserted in the main through a 1-in. stopcock. The upper ends of the tubes connect with the recorder. The chief feature of the recorder is a watertight chamber containing an expanding diaphragm of 10 sections, fixed at one end to the chamber wall. The interior of this compound diaphragm is connected with the up-stream orifice. The chamber itself is in connection with the down-stream mouth. The difference in pressure causes the diaphragm to expand and this movement is utilised to cause a pivoted magnet bar to swing on its centre. This swing is communicated through the wall of the chamber to another pivoted magnet outside, thus dispensing with a packed gland, and the frictional losses which would be involved therewith. To the outside magnet bar is fixed a toothed quadrant which is geared to a spindle on which is mounted a spiral. Upon the edge of the latter rests the arm of a pen, and the position of the spiral regulates and limits the downward movement of the pen. At intervals the pen is raised $\frac{1}{4}$ in. by clockwork and allowed to fall, and thus a broad curve is drawn on a circular chart, the outer edge of which is a true record of the movement of the diaphragm and hence of the flow in the pipe.

At the stand of Messrs. George Kent, Limited, a variety of the firm's meters are shown, including several types from the small integrating pipe meters of different patterns to Venturi tubes and Venturi recording meters. The latest type of Messrs. Kent's Venturi recording meter shown, specially designed for pulsating flows, was illustrated and described in ENGINEERING in our issue of January 4 of this year (page 7 *ante*). In this meter means are provided of damping out the effect of pulsations due to the

action of reciprocating pumps, or rather of averaging the rate of flow. The pulsations are conveyed to the U-tube of the meter with as little loss as possible by means of large tube connections. In one leg of the U is a float, rising and falling with the level of mercury in the U. The float is coupled with the registering mechanism by a special jointed link gear. This, in conjunction with the peculiar shape given to the back limb of the U of the meter, causing a large rise of the float for small differences of pressure and a smaller rise for the larger differences, produces on an horizontal spindle an angular displacement proportional to the rate of flow. This displacement is transmitted to a damping gear, which depends for its operation on the tension of a helical spring, and the pen coupled to this gear gives an average of the flow, without pulsation. Under many conditions the damping gear is not essential. For further details of this meter we must refer readers to the article referred to above. We may add that one of these meters is in use in the Exhibition power house for measuring condensate flow.

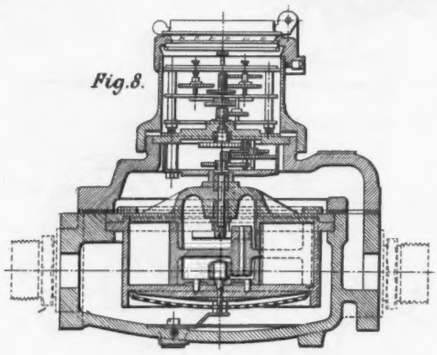


Fig. 8.

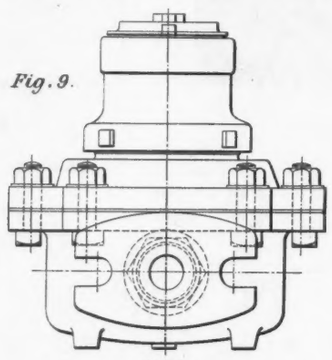


Fig. 9.

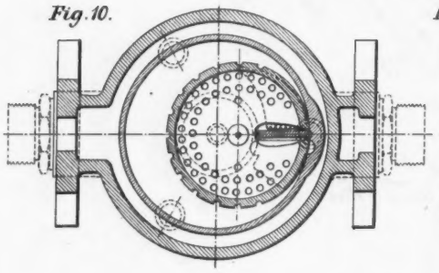


Fig. 10.

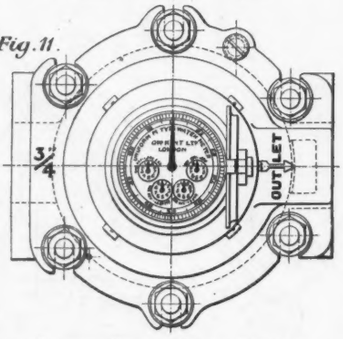


Fig. 11.

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FIGS. 8 TO 11. UNIFORM "M" TYPE WATERMETER; MESSRS. GEORGE KENT, LIMITED.

At the stand may also be seen examples of Messrs. Kent's "Inferential" meter of the fan rotor type; the Torrent meter, of the helical rotor type; and others of the packed piston type. One of the latest modifications is to be seen in the firm's "House" and "M" type meter, the chief features of the new "M" type being illustrated in Figs. 8 to 11 herewith. In both these meters a piston or displacer of drum shape is used, slotted at one point and working about a vertical fin projecting from the inside of the circular meter chamber. A vertical lug projects from the centre of the bottom of the circular meter chamber, and a projection at the centre of the displacer makes contact with this, so that the drum is forced to move eccentrically to the meter chamber. Its motion is in a circular orbit round this centre lug, the vertical fin preventing it from revolving. The ports are arranged one on either side of the fin, one for the outlet being in the cover of the meter chamber, and one for the inlet being in the chamber bottom. Water cannot pass from one port to the other without moving the displacer, which is kept in motion by the water pressure being exerted first inside the drum, then outside as well, and finally outside only, the remaining space in the chamber being open to the outlet. The circular movement of the displacer is utilised to drive, by means of an upstanding projection at the drum centre, a vertical spindle fitted with a T-head. At the upper end of this spindle is a pinion driving a train of robust celluloid gears, from which in turn the counter mechanism above is worked. The whole of the latter is protected from water by a rubber-packed joint at the rim of the case, and packed gland for the driving spindle. One of the features of the new meter is that the interior is circular and can, therefore, be finished accurately in the lathe. The bottom plate of the meter chamber is detachable and can be faced up and replaced without alteration in the depth of the chamber. The walls of the displacer will be seen to be grooved, this form being adopted with the object of allowing grit passing through to escape without scoring the walls or piston.

The provision of the central lug or hub, which is fitted with a gun-metal sleeve, round which the displacer moves, relieves the chamber walls of a good deal of the thrust of the piston, and consequently reduces the wear and tear on them. The single-moving part is also circular and machine finished. The meter is positive and involves no "slip," the total flow being checked and registered.

Among other appliances at Messrs. George Kent's stand may be mentioned the firm's waste-detecting meter, used for detecting fine flows at times when there should normally be no flow at all, and various water-level recorders, including the audible type, which gives a telephonic announcement of the depth of water in a reservoir at a distance. In this arrangement a gramophone mechanism is utilised to give the reading and an ordinary telephone circuit is employed so that by calling up the right telephone number information may be obtained of the depth given in feet and decimals of a foot. We may mention that Messrs. Kent's water meters are used in various ways in the exhibition both by other exhibitors and also in connection with sanitary and other services.

THE ELEMENTS OF MAGNETIC ANALYSIS.

By ELLIS H. CRAPPER, M.Eng., M.I.E.E.

(*Continued from page* 662.)

THE dissipation of the energy involved in the cyclic-process of magnetisation demands an expenditure of energy which is derived from the magnetising system, and, this energy loss, in ergs per cubic centimetre of the material per cycle, is given by $\frac{1}{4\pi}$ times the area of the closed hysteresis loop, *i.e.*, by $\frac{1}{4\pi} \times \int H \times \partial B$. The late Dr. Steinmetz was the first to prove that w_h, the energy loss in ergs per cubic centimetre per cycle, is given by the empirical relationship

$$\text{ergs. per cycle per cub. cm.} = \eta\, B_{max}^{1.6}$$

in which η is the Steinmetz coefficient, the magnitude of which depends upon the magnetic quality of the material. The total loss due to hysteresis for a sample of iron or steel is thus

$$W_h = \text{Vol.} \times f \times \eta \times B_{max}^{1.6}$$

Furthermore, the rate of dissipation by hysteresis is indicative of the magnetic hardness of the material.

Loss of energy is also occasioned when an alternating magnetic flux pulsates through an iron core as the results of eddy currents set up, and experiments prove that the eddy current loss is given by

$$W_e = \text{Vol.} \times \epsilon \times f^2 \times t^2 \times B_{max}^2$$

in which ϵ is the eddy-current loss coefficient. The total iron loss is therefore given by $W_i = W_h + W_e$.

Furthermore, the area enclosed by the demagnetisation curve between the remanence and coercive-force points and the two axes enables one to obtain a measure of the external magnetic energy available in the magnetic field between the pole-pieces of a magneto magnet. Mr. S. Evershed, M.I.E.E. has shown that by taking the products of the successive values of the demagnetising-force, — H, into the corresponding values of B, given by the demagnetisation portion of the descending curve of the hysteresis loop, a series of energy products, $\beta\,\phi$, is obtained, which, when plotted to the right of the B-axis, as shown in Fig. 15, gives the measure of the maximum value of the product, $\beta\,\phi_{max}$ of B and — H. The curve thus obtained approximates to the parabola, as indicated by the curves of the demagnetisation portions of the hysteresis loops of six representative magnet steels, *i.e.*, carbon, chrome, tungsten, permanite, cobalt and the K.S. cobalt steel in Fig. 15.

The following aspect of the problem is interesting: Select any two points x, y and x_1, y_1 on the $\beta\,\phi$ curve for a given magnetic material, and assuming that the parabolic characteristic holds, we may write the two following equations:—

$$\left.\begin{aligned} y &= a + b\,x + c\,x^2 \\ \text{and}\quad y_1 &= a + b\,x_1 + c\,x_1^2 \end{aligned}\right\}$$

from which we get

$$y - y_1 = b\,(x - x_1) + c\,(x^2 - x_1^2)$$

whence

$$\frac{y - y_1}{x - x_1} = b + c\,(x + x_1)$$

which is an equation of the first degree, and of the form of an equation to a straight line; consequently the plot of x and $\frac{y - y_1}{x - x_1}$ is a straight line. In other words, the measure of the energy corresponding to the area of the $\beta\,\phi$ curve, may be expressed as

$$E = a\,B + b\,B^2$$

and

$$\frac{E}{B} = a + b\,B.$$

Whilst it is usually assumed that the hysteresis loss in iron and steel is proportional to $\eta\,B_{max}^{1.6}$, it may be necessary in some cases to ascertain the precise value of the hysteresis index. A convenient method of doing this is to build up an Epstein square with a suitable number of strips of the material, and to wind it with a number of magnetising-turns, S, according to the alternating E.M.F. available. It will be assumed that the frequency f may be changed as desired, and that the applied voltage may be adjusted to E_1 and E_2 volts, so that four power measurements may be obtained by means of a wattmeter inserted in the magnetising circuit. The measures of the voltage applied must be obtained by an electrostatic voltmeter of suitable range, and means should exist to allow for the determination of the small copper loss. From first principles, the factors associated with the

measure of the applied E.M.F. are given by the fundamental equation of the alternating-current transformer, *i.e.*

$$E = \sqrt{2}\,\pi f A_i B_{max} S\ 10^{-8} \text{ volts},$$

whence $$B_{max} = \frac{f^{-1} E\ 10^8}{\sqrt{2}\,\pi A_i S}$$

Let $$k = \frac{10^8}{\sqrt{2}\,\pi A_i S}$$

then $$B_{max} = k E f^{-1}$$

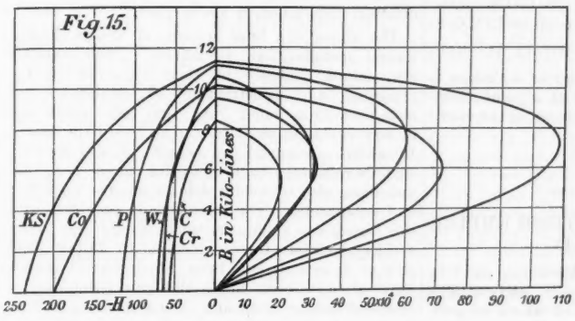
Assuming that the hysteresis index is x, the usual measure of the iron loss will be given by the equation

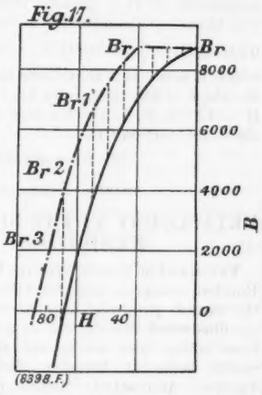
$$W_i = V \left\{ \eta f B_{max}^{\ 1.7}\ 10^{-7} + \epsilon f^2 t^2 B_{max}^2\ 10^{-8} \right\} \text{ watts}$$

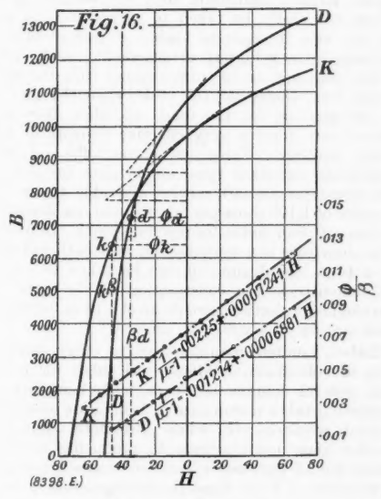
$$= V \eta f \left(k E f^{-1}\right)^x 10^{-7} + V \epsilon f^2 t^2 \left(k^2 E^2 f^{-2}\right) 10^{-8} \text{ watts}.$$

and $$x = \frac{\log \left[\frac{W_1 - W_3}{W_2 - W_4}\right]}{\log \frac{E_1}{E_2}}.$$

At this point it is worthy of note that Continental engineers have for a considerable number of years attached great importance to the investigation of the nature of the slope of the demagnetising portion of the curve of the hysteresis loop in the case of permanent magnet steels, especially at the remanence point, and have used a type of derived constant expressing numerically a measure of what is termed the *magnetic rigidity* or *stability* of a permanent magnet. This measure is obtained by introducing a tangent to the curve at the intersection with the B-axis. Originally, the value of the rigidity measure was assumed to be given by the intercept made by this tangent on the H-axis. In the opinion of the author, a more satisfactory measure of the rigidity number is given by the tangent of the angle which this line makes with the B-axis—a definite scale value for the B and —H measures being fixed in order that the results may be readily compared; in other words, ϕ/β, gives the measure of the tangent of the angle made by the line so introduced, as shown in Fig. 16.







Let $V\eta\ 10^{-7} = a$ and $V\epsilon\ t^2\ 10^{-8} = b$

then $$W_i = \left\{ \left(a k^x E^x f^{-x} \times f \right) + \left(b f^2 k^2 E^2 f^{-2} \right) \right\} \text{ watts},$$

$$= a k^x E^x f^{1-x} + b k^2 E^2 \text{ watts}.$$

Denoting $a\ k^x$ by c and $b\ k^2$ by d,

$$W_i = \left\{ c E^x f^{1-x} + d E^2 \right\} \text{ watts}.$$

Taking the wattmeter readings when the frequency is f_1 for pressures E_1 and E_2 we have

$$W_1 = c f_1^{1-x} E_1^x + d E_1^2$$

$$W_2 = c f_1^{1-x} E_2^x + d E_2^2,$$

and for a frequency f_2 for pressures E_1 and E_2 we have

$$W_3 = c f_2^{1-x} E_1^x + d E_1^2$$

$$W_4 = c f_2^{1-x} E_2^x + d E_2^2$$

then $$\frac{W_1 - W_3}{W_2 - W_4} = \frac{c E_1^x \left\{ f_1^{1-x} - f_2^{1-x} \right\}}{c E_2^x \left\{ f_1^{1-x} - f_2^{1-x} \right\}} = \frac{E_1^x}{E_2^x}$$

Fessenden* many years ago introduced the view that "the rate of variation of magnetisation with changes in the magnetising-force is proportional to the square of the magnetic susceptibility of the material, or $\frac{\delta I}{\delta H} = c \left(\frac{I^2}{H^2}\right)$ at the point under consideration." In the opinion of the author, the rate of the changes in the magnetic intensities during magnetisation depends upon the elastic properties of the material, and a preliminary investigation has given emphatic evidence that each magnet has a perfectly definite *magnetic elastic limit* which is readily determined and forms a most important constant of a magnet.

The method adopted by the author in this investigation, is to use a special type of moving-coil permeameter with soft-iron projecting pole-pieces for supporting the magneto-magnet to be tested, and which provides the magnetic field in which the moving coil is situated. Upon sending a small current through the moving coil a definite deflection results, the magnitude of which is indicated by a light pointer attached to the moving element. Suitable demagnetising coils are provided, and when the instrument is in use, the deflecting force is gradually diminished by gradually demagnetising the magnet under test, and the changes in the deflections enable the changes in the intensities of magnetisation to be ascertained by means of the calibration curve of the instrument for the current traversing the moving element. Different degrees of sensitivity may be obtained by varying the current sent through the moving coil.

The method of procedure adopted to get a measure of the magnetic elastic limit will be apparent from the results of a test given in Table V and by the curves in Fig. 17. The demagnetisation portion of the loop from B_r to H_c is obtained by the usual method, and after the magnet to be tested has been flashed it is placed on the permeameter with the demagnetising coils in position, but in the neutral condition, and the permeameter gives the reading corresponding to B_r. Current is then supplied to the demagnetising coils, and, in the case under consideration, it was decided gradually to increase the demagnetising force by steps of eight units of negative H, and it was found, as shown in the diagram (Fig. 17) that the magnet recovered its remanent value, B_r, up to 32 units of $-H$, after which the recovery fell off until the magnet was completely demagnetised. It is suggested that the magnetic elastic limit of a magnet be expressed tentatively by the measure of the maximum of the demagnetising force, $-H_d$, through which the magnet recovers its value B_r when $-H_d$ is removed, expressed as a percentage of H_c. In the example the diagram gives it as 45·4 per cent.

TABLE V.

$-H_d$	B_d	B_{rec}
0	8750	8750
−8	8550	8750
−16	8200	8750
−24	7700	8750
−32	7050	8750
−40	6200	8250
−48	5100	7550
−56	3600	6700
−64	1750	5500
−72	−500	3800
−80	−3600	1650

The magnitude of the hysteresis constant η of magnetic materials varies considerably according to the grade of the iron and steel in use, and is indicative of the degree of magnetic hardness of the material. Table VI gives the values of η for the ordinary magnetic substances in general use.

TABLE VI.

Stalloy	$\eta = 0{\cdot}0012$
Lohys	$\eta = 0{\cdot}0016$
Pure iron	$\eta = 0{\cdot}003$
Electrolytic iron	$\eta = 0{\cdot}009$
Soft cast steel	$\eta = 0{\cdot}003$ to $0{\cdot}009$
Cast steel	$\eta = 0{\cdot}012$
Cast iron	$\eta = 0{\cdot}013$
Forged steel	$\eta = 0{\cdot}015$ to $0{\cdot}025$
Hard cast steel	$\eta = 0{\cdot}025$ to $0{\cdot}028$
Nickel	$\eta = 0{\cdot}013$ to $0{\cdot}04$
Hard tungsten steel	$\eta = 0{\cdot}058$

Obviously the hysteresis coefficient η is the opposite characteristic of a material to μ_{max}, so far as the nature and quality of the substance are concerned. Valluri was the first to announce that the product of the two factors, η and μ_{max}, approximates to a constant for a given class of magnetic material; thus, the magnitude of this product for Mme. Curie's series of carbon steels is as follows:—

TABLE VII.

Composition.	Product ($\eta \times \mu_{max.}$)
C = 0·2	0·0086 × 450 = 3·87
C = 0·49	0·01456 × 245 = 3·5672
C = 0·085*a*	0·0322 × 96·5 = 3·1073
C = 0·85	0·04511 × 86 = 3·8795
C = 0·96	0·0334 × 93 = 3·1062
C = 1·21	0·356 × 96·5 = 3·4354
	Average = 3·494

Magnetic Viscosity.

Whilst the linear relationship, $\rho_i = a + b$ H, expresses in a perfectly simple manner how the intrinsic reluctivity of a magnetic material is related to the magnetising-force throughout the major portion of the ascending magnetisation curve, it is important to observe that a distinct inflection occurs in the early part of the B/H curve below the point of maximum permeability, μ_{max}, and this implies somewhat erratic changes in the flux distribution with consequent apparent deviations from the hyperbolic relationship, assumed to exist between the intensity of magnetisation, I, and the magnetising-force, H. Tentatively, this behaviour may be explained by the fact that within a certain range of low magnetising-forces—which depends upon the quality and degree of hardness of the material—the reluctivity *diminishes* more or less uniformly as the magnetising-force is *increased*, whilst for inductions above the critical point of maximum permeability, the reluctivity *increases* uniformly. The change-point in the rate of change of the reluctivity is indicated by the existence or presence of a bend in the reluctivity

* Physical Review, Vol. ii, February, 1900.

curve, indicating the termination of the *apparent decrease* in the reluctivity with *increase of magnetising force*, as clearly indicated in Fig. 8, page 601 *ante*.

Dr. Steinmetz terms the range through which the phenomenon of decreasing reluctivity exists *the stage of magnetic instability*, the extent of which depends mainly upon the degree of *homogeneity* of the material. In the case of *heterogeneous* materials or alloys, which form the magnetically-hard magnet steels, there appears to be present two or more component elements possessing distinctive and different magnetic characteristics so far as their individual magnetisabilities are concerned, with the result that the flux-density will be different for a given applied M.M.F. in the individual component elements. Naturally the magnetically-soft component will be the more responsive, and consequently more readily magnetised, until its permeability has diminished to a certain value corresponding to a certain magnitude of the applied H, at which the magnetically-hard component becomes more responsive; ultimately the abnormal state gives way to a more uniform resultant condition as regards magnetisability. Such a variable stage in the magnetisation, or period of delay in the building up or orientation of the molecules of the component elements, would appear to be consistent with the period of decreasing reluctivity of the compound.

It is probable, however, that the phenomenon of the early sluggish movement of the molecular magnets—frequently termed *magnetic viscosity*—is due to a number of causes. The fact, for instance, that the bend in the reluctivity curve disappears when the sample under test is tapped or is traversed longitudinally by an alternating current whilst the test is being made, has been well known for a considerable period of time and indicates that it is a super-imposed effect of the nature of molecular friction, associated with the phenomenon of magnetic hysteresis, inasmuch as it is more pronounced in the case of materials possessing a high value of the hysteresis constant, η, and is less marked in the case of samples tested in the form of laminations than with samples of the same material in the more solid form, although the existence of scale with laminations is found to be detrimental.

It is also suggested that the variable time-lag aspect of magnetic viscosity may be influenced by the magnitude of the cross-sectional area of the sample under test on account of the possibility of a variation in the degree of the penetration of the magnetising influence, according as the cross-sectional area is large or small, giving rise to the production of eddy currents on account of the different rates of change in the flux in the material itself, which would tend to oppose and retard the change in the flux, and form a type of skin-effect action.

Whatever may be the cause of viscosity, the effect is found to be more pronounced if the magnetism be taken from a certain small positive value to a similar negative value, than when decreased through the same range from a larger positive value to a smaller negative value.

In order to bring out prominently the variable character of the reluctivity curve during the early stages of magnetisation, several curves were given in Fig. 8, page 601 *ante*; thus, the B / H, μ / B and $\frac{1}{\kappa}$ / H curves give the magnetic characteristics of a sample of good soft iron, tested in the ring form at the Research Department of the General Electric Co., America, by Mr. J. D. Ball. As will be observed, two ranges of the magnetising-force H are considered; one for H = O to H = 12 C.G.S. units, and the other for H = O to H = 150 C.G.S. units.

The B / H curve, I, reveals very clearly the inflection in the magnetisation curve between the values of H from 0 to 1·5 C.G.S. units. The μ / B curve requires no comment, beyond the statement that the maximum value of the permeability, μ_{max} is approximately 3950, and corresponds to a flux-density of 4375 units, thus giving the associated magnetising-force H = 1·1. The magnetisation curve II indicates the general hyperbolic characteristic, and the corresponding reluctivity curve E F admirably represents the linear relationship which exists between $\frac{1}{\kappa}$ and H for the higher values of the magnetising force, Frohlich's equation for which is $\frac{1}{\kappa} = 0{\cdot}00921 + 0{\cdot}000{,}6023$ H. This value of $\frac{1}{\kappa}$ is taken as the *normal* value.

For the lower values of the intensity of magnetisation, the reluctivity curve is ABCD, which indicates very clearly that there are two characteristic change points at B and C, and that the reluctivity decreases from 0·008 to 0·0031 during the period that the magnetising-force H increases from 1·1 to 1·75 C.G.S. units. The linear equation for the portion B C of the curve is $\frac{1}{\kappa} = 0{\cdot}01319 - 0{\cdot}00567$ H. The remaining portion of the curve commences with a definite curvature as the reluctivity increases, and the *normal* value of $\frac{1}{\kappa}$ is not attained until the magnitude of H is greater than 10 C.G.S. units. The linear equation for the section up to 12 C.G.S. units of H, is $\frac{1}{\kappa} = 0{\cdot}00104 + 0{\cdot}007372$ H, from which it is obvious that there must be a change in the slope of the reluctivity curve at a point above H = 12 C.G.S., at which a kink occurs in the curve above the portion CD.

(To be continued.)

METALLURGY AT THE BRITISH EMPIRE EXHIBITION.—IV.

THE stand of Messrs. William Beardmore and Co., Limited, covers an area of 5,456 sq. ft., and contains the express passenger locomotive of which we gave an illustrated description on page 665 *ante*. The head offices and works are at Parkhead, other works being at Dalmuir, Mossend, Coatbridge, Paisley, Anniesland, Airdrie, and Bootle near Liverpool. The metallurgical products of the firm are made mainly at Parkhead and Mossend; we described these latter works in our issue of October 13, 1922, and following issues. The products of Parkhead include practically everything from the raw steel to the finished article, these comprising, notably, intricate steel castings of great size and weight, for the machining of which a series of heavy machine tools is available, combined with the necessary equipment for handling the pieces in course of machining. Actual exhibits of steel castings made at the Parkhead works might have included battleship rudder frames weighing over 50 tons, rudders for passenger liners, propeller shaft brackets for battleships, rolling mill housings, hydraulic press crossheads, among other ship and engineering material, but these would have been too heavy and too large to deal with at the Exhibition, and in their place models have been displayed which, to an untrained eye, do not convey an accurate impression of the dimensions of the real pieces which they represent. Smaller castings illustrative of the firm's new electric foundry products at Mossend form part of the exhibits; they include valve castings, and castings for locomotives comprising a driving wheel, a bogey wheel, a hind footplate and a front drag and slide bar bracket. The forge department displays a group of forgings and drop forgings which include gear pinions and two turbine wheels. The smaller wheel is 4 ft. 2 in. in diameter, the larger one 7 ft.; they are of nickel-chromium steel. The armour plate rolling mills, one of the important departments of Messrs. Beardmore's works, have supplied to the stand an armour plate weighing approximately 16 tons. This is a tapered, curved plate, 6 in. thick at one end and 3 in. thick at the other 11 ft. 6 in. high and 10 ft. 3½ in. wide on the outer surface. Five rounds were fired against the plate, two from a 9·2-in. gun, the higher striking velocity having been 1,349 ft./seconds, and three from a 12-in. gun, the highest striking velocity in this case having been 1,396 ft./seconds. Near the plate is an armour tube for an ammunition hoist, which has withstood several rounds from a 6-in. gun, firing 100-lb. capped armour-piercing shell; the tube weighs about 5 tons and is 4 in. in thickness. The wheel and axle works and tyre mills are represented by a group of rough castings and machine-finished articles, including locomotive driving wheels, bogey wheels and semi-finished tyres and axles. A specimen of the Blake patent boiler represents one of the specialities made in the Beardmore boiler department at Parkhead; this is shown complete, with smokebox, funnel, mountings and firebricks. The forge machine shops are represented by cut gears; the flanging and boiler flue department by a flanged marine corrugated furnace flue; whilst the motor-car frame department shows lorry and taxi chassis frames. The Mossend steelworks exhibit a case of rolled steel sections, illustrating the great variety of work of this kind which they are able to undertake, one of their latest and most successful specialities being the rolling of rails. They have booked large orders for these during the last two years. A group of test pieces which come from the steelworks test department at Parkhead show the behaviour of various qualities of Beardmore steel under the different tests which it has to pass.

The above is a brief account of Messrs. Beardmore's metallurgical specialities. Their exhibits also afford evidence of their activities in the designing and construction of ordnance, and include a 15-in. inner "A" gun tube which was in service during the late war on board the Queen Elizabeth. A model can be seen of a 4-in. twin anti-aircraft high-angle gun for naval use, the gun being also suited for defence against torpedoes and submarines. The mounting is provided with the Beardmore rolling friction training gear. The artillery exhibits further include an 18-pdr. field gun of a new design, from which 15,000 rounds have already been fired, the gun remaining in excellent service condition. There is also a 40-mm. 2-pdr. infantry anti-tank and anti-aircraft gun, which can easily be taken to pieces and carried by five men in separate loads. A feature of the carriage is the split trail arrangement; each shaft of the trail can be so turned round that the pair either form shafts for the mule when the gun is in the position for the road, or, when they are opened out, form a very effective support in the firing position. Three automatic rifles, of the Beardmore-Farquhar type, are in close proximity, one fitted for aircraft service and able to fire at the rate of 1,100 shots per minute, and one designed to take a 0·5-in. bullet for repelling tanks. A model in a show case is a reproduction one-tenth full size of a 15-in. naval gun; it can be taken to pieces to demonstrate the construction of the gun. A pyramid of projectiles is made up of a 15-in. howitzer shell resting on six 60-pdr. ones.

Tubes, Limited, manufacturers of every description of cold-drawn weldless steel tubes for naval and general commercial work, make a feature of producing tubes manufactured from alloy steels for special requirements, while Bromford, Limited, confine their manufactures to producing weldless tubes for all purposes where hot finished material is required. These firms the headquarters of both of which are at Birmingham, are showing a variety of their specialities. The most prominent specimen is a cold-drawn steam expansion bend, 10¼ in. in outside diameter by 15 ft. high on the bend. Other classes of work include cold-drawn steel marine boiler tubing representative of their work for the boilers of H.M.S. Rodney, one of the Admiralty's battleships now building. Their marine boiler tubes are cold drawn to all sizes from 1¼ in. to 10½ in. outside diameter, with no restriction as to gauge. Other cold-drawn steam tubes on the stand are specimens of those they have supplied for the boilers of the Berengaria. A length is shown of a steel cold-drawn steam distribution pipe, 15 in. in diameter, made to Admiralty specification for the steam service of the navy. The display also includes representative elements of locomotive superheaters, including cold-drawn steam tubes and "spear-heads," the latter stamped out in one piece for oxy-acetylene welding to the steam tubes. These companies made all the tubes for the Thompson water-tube boilers at the Exhibition power house, which we described on page 363 *ante*. The quality of the material is illustrated by a piece of a steel boiler tube turned back upon itself, inside out, cold, without trace of fracture, and also by various

cold crushing tests. Other exhibits are a hot-rolled steel wobbler muff; hot-rolled steel spigot and faucet pipes for water and gas mains; an electric tramway standard, stepped, in one piece, hot rolled; weldless steel back axles and torque tubes, flanged and tapered, for automobiles; and specimens of threaded stay tubes, which are manufactured up to 8 in. outside diameter. Various pipe joints are also shown, including a patented form of Bromford, Limited. In this the tube end is flanged back into a sharp outside shoulder on which rests the joint casing, the inside bore remaining smooth throughout without any obstruction or cavity at the joint. Among other interesting specimens may be mentioned a sample of the weldless steel S. & F. hot-rolled tubular colliery pit-prop, at the base of which fits a loose hollow funnel-shaped adapter. The prop rests on the floor of the mine on a short piece of timber prop, about 15 in. in length, driven in the base of the adapter. The prop itself rests on the adapter. A steel wedge near the top of the prop, under an extension piece which has a travel of about 6 in., keeps the prop to its full extended length, a wooden "lid" or timber block being placed between the head of the extension piece and the roof. The prop is easily placed in position. In order to increase its height, where necessary, a second adapter is added on top of the former one. Among the advantages of the device are saving in timberage and ease in fixing and withdrawal—the withdrawal requiring only the drawing out of the wedge, when the prop extension falls back and the prop is free. The adapter alone, a small light piece, need be sent up to the surface for insertion at its base of a fresh piece of timber, the steel prop itself, the heavier component part, remaining in the pit.

Adjoining the stand of Messrs. Tubes and Bromford, Limited, is the display made by Messrs. Accles and Pollock, Limited, Oldbury, which contains a large variety of specimens of worked-up steel tubes, for oil drills, kerb-side petrol pumps, aeroplane parts, &c., also all kinds of special section tubing, tapered tubes and others for motor-car construction, and a large range of butted tubes for motor cycles. Steel tubular shafted golf sticks are also exhibited, and a model of a wireless telescopic mast.

Messrs. Latch and Batchelor, Limited, Hay Mills, Birmingham, who are amalgamated with Messrs. Webster and Horsfall, a firm which was established in 1730, have provided both winding ropes at the Exhibition colliery; one of these is a locked-coil rope, the other being a flattened-strand rope. Both are made of their special rust-resisting wire. Messrs. Latch and Batchelor claim to be the original patentees of both these types of ropes; they were invented by them in the years 1884 and 1888 respectively. The two particular ropes at the colliery are 1¼ in. in diameter. They are of the best "plough steel" having a tensile strength of 110 tons per square inch. The flattened-strand rope has an actual breaking strain of 62 tons, whilst that of the locked-coil rope is 85 tons. The breaking strain of a locked-coil rope is generally about 44 per cent. higher than that of an ordinary rope of the same material and diameter. This increase in strength allows a smaller diameter rope to be used with a corresponding reduction in side friction on drum and pulleys and further allows a reduction in width of the drum. The locked-coil ropes are absolutely free from any tendency to twist, and the firm can give instances of lengths of over 2,400 ft. long used for sinking purposes without a single turn. The outer wires exactly filling the outer periphery, a maximum bearing surface is secured, the smooth periphery reducing vibration to a minimum. Messrs. Latch and Batchelor's flattened-strand type of rope has in the centre of each strand either a triangular wire or a triangle formed of three or six wires, the apex of the triangles in both instances being towards the centre of the rope. The effect of the arrangement is to bring a larger number of wires to the outside of each strand and hence to the periphery of the rope, thereby "flattening" each strand and giving to the rope a correspondingly greater wearing and bearing surface, at least 150 per cent. in excess of the wearing surface of ordinary ropes. These ropes are exceedingly flexible and are less liable than ordinary ropes to be put out of shape by the crushing action they have to sustain. In the simpler construction they can be laid either "Lang's lay" or ordinary lay, whilst in the more complicated form they can be rendered non-twisting which is very essential to successful sinking or winding.

Messrs. Latch and Batchelor have in the Palace of Engineering a very complete display of specimens of their various cables, including the two above mentioned, also ordinary or "Lang's lay" winding ropes, locked-coil pit guide ropes, half-locked aerial ropes, &c. The sections of each are shown above the respective specimens by an interesting arrangement of mirrors. Other specimens include piano wires, fuse-spring wires, gun-winding wire for heavy guns and field guns, aeroplane and kite balloon ropes. A new type of oil-well drilling rope designed by them is of their flattened-strand manufacture; this is a five-strand, reverse-lay rope, giving high resistance to wear combined with flexibility and resilience, or "zip" as our American friends would qualify this latter special feature. It is interesting to note in connection with Messrs. Latch and Batchelor's exhibits that Mr. James Horsfall, a former partner of Messrs. Webster and Horsfall, with whom the present firm amalgamated as above stated, was the inventor, in 1856, of the "patenting" process, a process which made it possible to produce ductile wire having a tensile strength up to 200 tons per square inch. During the Great War 90 per cent. of the firm's output capacity was diverted to war purposes in the shape of short fuze-springs and fuze-spring wire, of which they manufactured very large quantities for the British navy and army, and for most of the allies, also in the shape of wire for gun-winding, aeroplane wire, control cables, marine and other cables.

Messrs. Richard Johnson and Nephew, Limited, Bradford Iron Works, Manchester, an old-established firm which dates from 1773, manufacture all classes of iron, steel and copper rods and wire of all sizes down to the finest gauge. They have specialised for many years in the manufacture of wire for electric cables, and state that the first submarine cable was sheathed with their wire for its armouring. Their steel wire has also entered into the manufacture of a large number of suspension bridge cables. Their specialities further include fencing strands and telegraph strands. They state that they were the first makers of barbed wire in this country, and they show several coils of this wire. Other specimens include commutator bars, bus bars, trolley wire, drawn steel sections of all shapes for engineering purposes, a section of a billet followed by a section of the rolled rod, and by samples of drawn wire, including the thinnest specimens. A feature of the display are samples of cadmium-copper wire for electrical work; the firm make their own cadmium-copper alloy. In the centre of the stand is a piece of fencing wire to which is suspended a 1,000-lb. deadweight, the supporting framework being built up of billets.

The Kirkstall Forge, Limited, Leeds, have a very complete exhibit of their manufactures, including a bright steel, reeled, heavy straight shaft; a camshaft for a quartz-crushing machine as supplied to the South African gold mines; and textile spindle steel having a blue finish to stand varying climatic conditions. A drop forging is a double-basin, patent rear axle for a railless bus, in one piece, provided for transmitting the drive to the two wheels. The firm make both the single-basin and the double-basin type, and exhibit in the motor-car department a series of very interesting axles finished complete for various types of light and heavy motor vehicles, also a section illustrating the construction of their patent rear axle. This particular one is of the single-bowl type with arms drop-forged in one piece, eliminating all welded joints and making for a specially strong job. A 4-ton to 5-ton vehicle rear axle, which is fitted complete with brake drums, differential gear, &c., is noteworthy in that the worm gear is stated to have an efficiency of 97 per cent. Other drop forgings displayed by the Kirkstall Forge include motor-car front axles, swivels, steering forks, levers for all types of motor vehicles, also loom cranks, one being 9 ft. long, with two throws, made in one piece. Besides the drop forgings and the larger shafts to which we have briefly referred, the stand contains a very comprehensive selection of "Kirkstall" bright compressed shafting of smaller diameter, patent rolled shafting and bright compressed-steel sections.

The exhibit of the Staveley Coal and Iron Company, Limited, Chesterfield, affords evidence of the capacity of the company in the manufacture of cast-iron pipes and joints of all sizes and types for ordinary conduits and for high-pressure hydraulic power distribution. It also includes a ring of tunnel segments as used on the London electric underground railways. Besides this ring and the cast-iron pipe specimens, the displays of very numerous samples of by-products also claim special attention. The series is a very complete one, and comprises tarred slag, a high-grade road-making material made by the company from their specially prepared tar and blast-furnace slag, a compound which is rendered equal to granite by a patented process owned by them. It includes also ammonia products; coal-tar products; numerous acids; "Staveho"—this being a powder for mixing with cement to render the cement work impervious to moisture, the effect of which is permanent. On the side of the stand is a solid block of coal measuring 7 ft. by 4 ft. by 3 ft., taken from the "top hard" seam of the Markham No. 1 colliery.

THE SOUTHAMPTON 60,000-TON FLOATING DOCK.

AN important event in the history of the port of Southampton will take place on Friday next, the 27th inst., when the new 60,000-ton floating dock will be formally inaugurated by H.R.H. the Prince of Wales. The dock has been provided by the Southern Railway to enable even the largest vessels in the world, viz., the White Star liner Majestic and the United States liner Leviathan, using the port to be repaired and overhauled. These vessels, we may mention, are 956 ft. and 950 ft. in length overall, respectively, so that they could not be accommodated in the longest existing graving dock at Southampton, which has a length of 912 ft. 3 in. They can, however, be easily handled on the floating dock, which is 960 ft. in length. The floating dock will also be used for the Cunard liners Aquitania and Berengaria, since, although the latter vessel has been docked in the graving dock above referred to, the operation was a particularly difficult one owing to the fact that the vessel's overall length of 905 ft. left very little clearance at the ends. There are five other graving docks at Southampton ranging from 281 ft. to 745 ft. in length, so that with the new dock now available it will be possible to deal efficiently and economically with ships of all sizes.

We have already given some particulars of the floating dock on page 206 of our issue of February 15 last, and we now propose to describe it in greater detail with the aid of some drawings and photographs placed at our disposal by the designers, Messrs. Clark and Standfield, the builders, Messrs. Sir W. G. Armstrong, Whitworth and Company, Limited, and Mr. G. S. Szlumper, the general manager of the Southampton Docks of the Southern Railway. Of these, Figs. 1 and 2 on the next page are, respectively, a longitudinal section and a plan of the dock showing its general arrangement, while the engravings on Plate LXXVII (Figs. 3 and 4) illustrate its appearance. Fig. 3 has been reproduced from a photograph taken after the arrival of the dock at Southampton on April 21 last, while Fig. 4 is an end view of the dock lying off the fitting-out quay at the builder's yard; the two men standing on the pontoon deck in the latter illustration serve to give a good impression of the dimensions of the dock. An end elevation, on which the main dimensions are indicated, is given in Fig. 5 on Plate LXXIX, while Fig. 6, on the same Plate, is a photographic illustration taken during the progress of the work of securing the dock to its moorings at Southampton. Details of the mooring arrangements with a key plan showing the location are given in Figs. 7 to 21 on Plate LXXX, while Figs. 22 and 23 on page 791 show some of the dredging plant used for the preparation of the berth.

The dock is located, as shown on the key plan, Fig. 7, on Plate LXXX, a little back from Southampton Water, between the Town Quay and the

Trafalgar graving dock. To give the depth of water required for the submergence of the dock, it was necessary to dredge the area of the berth to a depth of 74 ft. below H.W.O.S.T., the dredged area being connected to the existing level of the sea bed by 3 to 1 slopes. Figs. 8 to 10, on Plate LXXX, show the previously existing levels of the sea bed, as well as those formed by the dredging operations. This work was carried out by the James Dredging Company, Limited, of Southampton and London, under the supervision of Mr. F. E. Wentworth-Shields, M.Inst.C.E., the Docks Engineer of the Southern Railway. The James Dredging Company employed for the work the new bucket dredger "Foremost," which we illustrate in Fig. 22, on page 791. This dredger, which was designed by the contractors, is of the non-propelling type, 200 ft. in length, 35 ft. in breadth, and 12 ft. in moulded depth, while its mean draught is 6 ft. 6 in. It has an open bow and is capable of cutting its own flotation, as well as of dredging to a maximum depth of 76 ft. The buckets, of which there are 63 in all, are each of 1 cub. yard capacity. They are operated by a 750-i.h.p. triple-expansion engine, which drives the upper tumbler through two special camel-hair belts, each 30 in. wide. The discharge shoots, visible in Fig. 22, were arranged exceptionally high to load the dredged material efficiently without swinging the vessel. For transporting the material to the depositing grounds, situated at a distance of 30 miles from Southampton, steam hoppers, also designed by the James Company, and illustrated in Fig. 23, on page 791, were employed. They are built, as shown in the illustration, with raised decks fore and aft to render them capable of proceeding to sea and depositing their loads in heavy weather. They are 180 ft. long, 33 ft. in breadth, and 15 ft. in moulded depth, and are propelled by triple-expansion engines. Steam gear is fitted for depositing the material from the hoppers and steam manœuvring winches are provided for handling the vessels alongside the dredger. The capacity of the hoppers themselves is 1,000 tons. but they are fitted for towing and were used for towing dumb hopper barges each carrying 2,000 tons of material. The dumb hoppers are provided with steam appliances for operating the doors, steam steering gear and other modern fittings. Two tugs were also used for towing the dumb hoppers. The work was carried on continuously day and night, night work being facilitated by powerful electric-light installations on all the plant employed. Altogether about 1,222,000 cub. yards of material was dredged and deposited without accident or serious delay, although some of the ground encountered was of a very heavy nature.

The dock is secured in position by a combination of chain moorings and booms, the general arrangement of which is indicated in the key plan, Fig. 7. Restraint in the fore and aft direction is provided by a system of four chain cables composed of 3 in. diameter stud links and each attached to a concrete block weighing 35 tons. The southern pair of anchor blocks are buried below the dredged line of the berth and from these the cables pass to the side walls of the dock near the northern end. This arrangement was adopted in place of the more obvious one of taking the blocks farther south and attaching the cables to the nearest end of the dock in order to avoid the possibility of the cables fouling the entrance to the Trafalgar dock. The arrangement of the moorings at the northern end is of the usual type, and the anchor blocks are buried in ground, which is uncovered at low water, close to the shore end of the Town Quay.

In the broadside direction, the dock is secured by four mooring booms on the eastern side, each boom being attached to a reinforced-concrete dolphin arranged as shown in the key plan, Fig. 7, and in the transverse and longitudinal sections, Figs. 8 to 10 on Plate LXXX. The mooring booms are of steel-lattice construction, 110 ft. in length, and are fitted at each end with a universal joint of the cruciform-pin type for connection to the dock and to the dolphin. The joints are designed to allow for the vertical movement of the dock, due to the tide and to the flooding and pumping operations involved in docking a ship. They also provide for the horizontal movement in the fore and aft direction due to the variations in the tensions on the mooring cables caused by wind pressure. This movement, however, is estimated not to exceed 20 ft. on either side of the normal position in any condition of the wind.

The dolphins, which are shown to a small scale in Figs. 8 to 10, and in greater detail in Figs. 11 to 21 on Plate LXXX are of unique design and, as will be seen from the illustrations, they consist of what may be described as large reinforced-concrete tables. All four of the dolphins are of practically identical design. The table top of each is a rectangular reinforced-concrete slab 70 ft. long, 32 ft. wide and 5 ft. deep, and it is supported on 16 in. by 16 in. reinforced-concrete piles arranged as shown in Figs. 11, 12, 13 and 15. There are 94 piles, ranging in length from 47 ft. to 66 ft., to each dolphin, and of these piles 44 are vertical, 21 are raked at an angle of 60 deg. towards the dock, and 21 are raked at the same angle away from the dock, as shown in Figs. 11 and 15. These piles, assisted by the weight of the slab, are designed to resist a horizontal load of 250 tons transmitted through the boom to the dolphin, either as a push or a pull. The four dolphins are thus capable of resisting a total horizontal load of 1,000 tons, which is the calculated maximum wind pressure on the dock when a large ship is raised in it. The eight remaining inclined piles in each dolphin are inclined in planes parallel with the longitudinal axis of the dock, six being located at the front end and two at the rear end, as shown in Figs. 12, 13 and 15. They are intended to resist the skew pull or push from the booms when the axes of the latter are not at right angles to the line of the dolphins. Fixed on the top of the reinforced-concrete slab which forms the cap of the dolphin, is a steel casting carrying the pin for the universal joint connection for the end of the boom. To the casting are attached steel anchor ties buried in a V-shaped concrete wall cast on to the upper surface of the slab, which is fully reinforced in all directions with steel rods so as to distribute the load uniformly to the piles. Detailed drawings of the anchorages are reproduced in Figs. 16, 17 and 18 on Plate LXXX, from which the arrangements will be followed without further explanation.

At high water, the caps of the dolphins are submerged, only the tops of the anchor-tie walls being exposed, as will be clear on reference to Figs. 11, 12 and 13. In order to warn vessels of the extent of the submerged portion, a timber structure has therefore been erected to a height of 6 ft. above H.W.O.S.T. on each dolphin. On the three southern dolphins (see Fig. 7) the timber structure is of a very light character, consisting simply of a series of posts and rails suitably braced, but on the dolphin at the northern end it is very substantial and is completely decked over. This dolphin is used as a means of access to the dock, a fixed steel bridge, indicated in Fig. 8, spanning the gap between the shore and the dolphin. The bridge rests on a concrete stool formed on the cap of the dolphin and illustrated in Figs. 19, 20 and 21; the location of the stool is indicated by the dotted lines in the bottom right-hand corner of Fig. 14. A gangway fixed to the top of the mooring boom gives access from the dolphin to the lower pontoon-deck level of the dock, an opening being formed through the dock wall for the purpose. When the dock is submerged, however, this gangway is, of course, also submerged, and an alternative means of communication between the dock and the dolphin is therefore

Fig. 1.

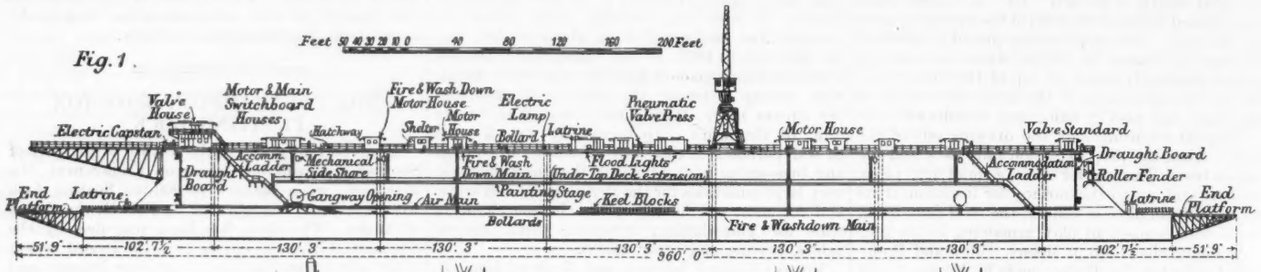
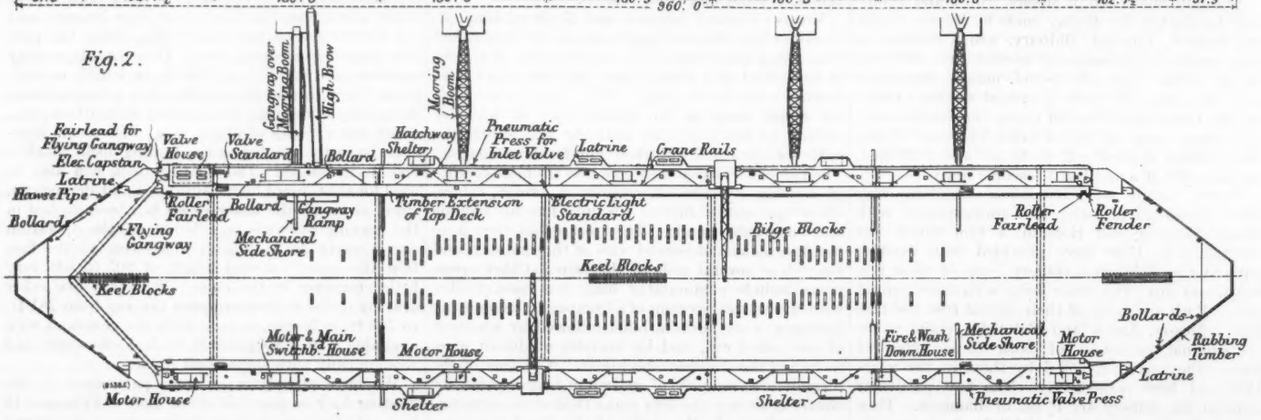


Fig. 2.



60,000-TON FLOATING DOCK AT SOUTHAMPTON.

CONSTRUCTED BY MESSRS. SIR W. G. ARMSTRONG, WHITWORTH AND CO., LIMITED, TO THE DESIGNS OF MESSRS. CLARK AND STANDFIELD.

(*For Description, see Page* 789.)

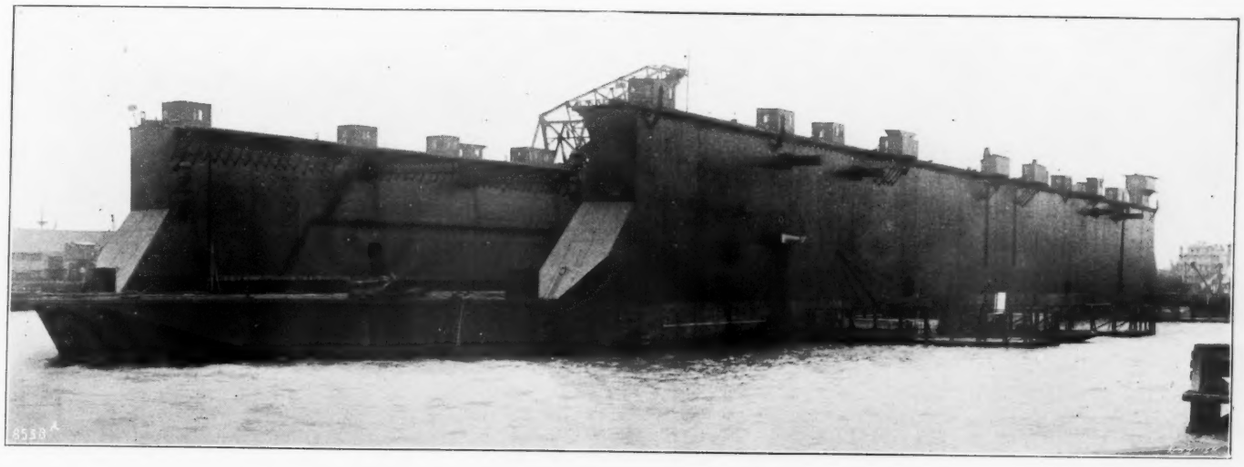


FIG. 3. THE DOCK LYING NEAR ITS MOORINGS AT SOUTHAMPTON.

FIG. 4. END VIEW OF THE DOCK TAKEN AT THE BUILDERS' FITTING OUT QUAY.

(*To face page* 790.)

60,000-TON FLOATING DOCK AT SOUTHAMPTON.

CONSTRUCTED BY MESSRS. SIR W. G. ARMSTRONG, WHITWORTH AND CO., LIMITED, TO THE DESIGNS OF MESSRS. CLARK AND STANDFIELD.

(*For Description, see Page* 789.)

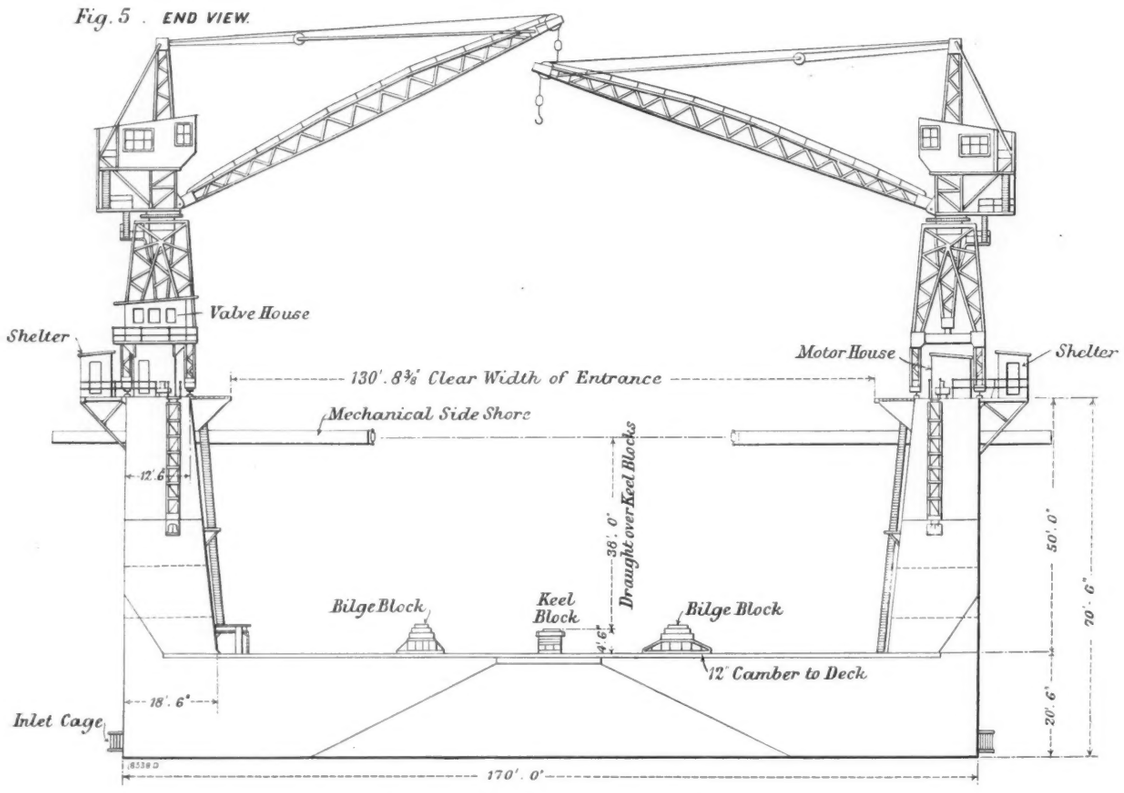


FIG. 5. END ELEVATION OF THE DOCK.

FIG. 6. LIFTING THE MOORING BOOMS FROM THE DOCK AT SOUTHAMPTON.

MOORING ARRANGEMENTS FOR 60,000-TON FLOATING DOCK AT SOUTHAMPTON.

MR. F. E. WENTWORTH-SHIELDS, M.INST.C.E., DOCKS ENGINEER, SOUTHERN RAILWAY.

(For Description, see Page 789.)

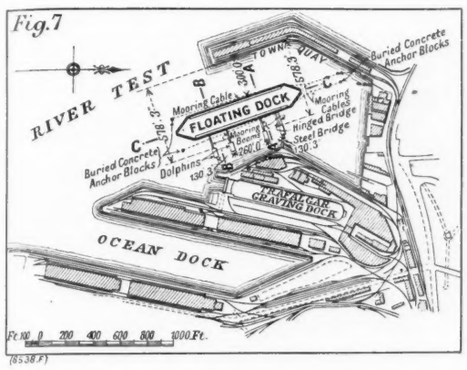
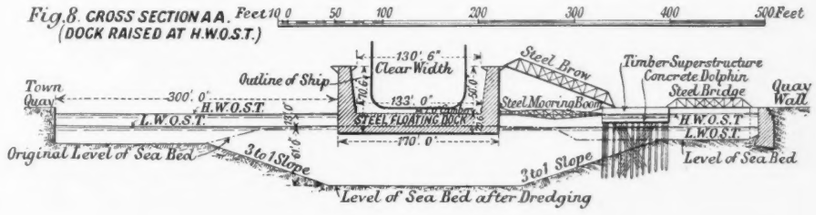
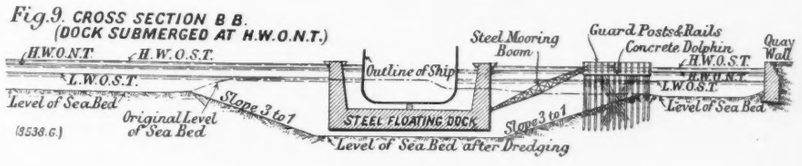


FIG. 7. KEY PLAN SHOWING LOCATION OF DOCK.





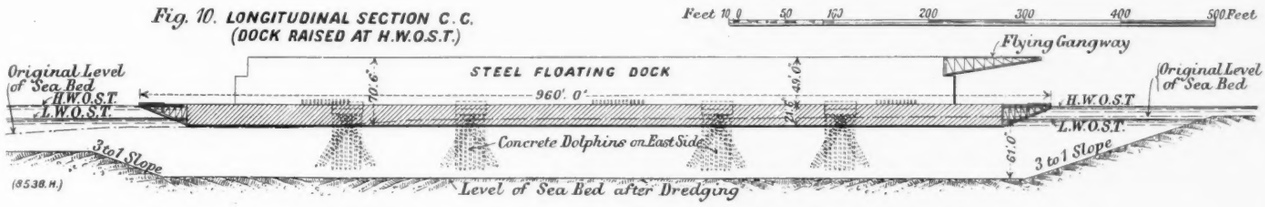
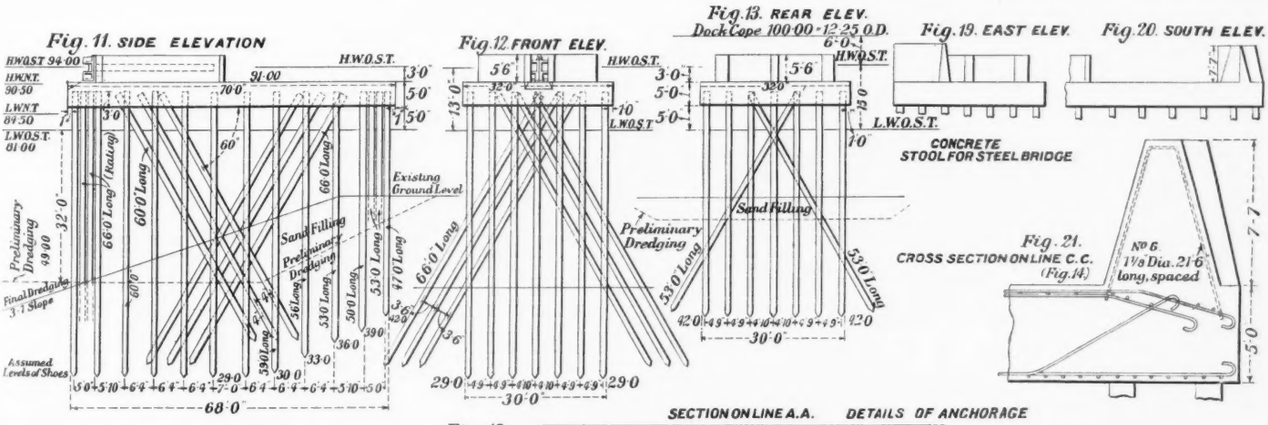


Fig. 10. LONGITUDINAL SECTION C C. (DOCK RAISED AT H.W.O.S.T.)
Feet 10 0 50 100 200 300 400 500 Feet
Flying Gangway
Original Level of Sea Bed
H.W.O.S.T.
L.W.O.S.T.
STEEL FLOATING DOCK
960' 0"
Concrete Dolphins on East Side
3 to 1 Slope
Level of Sea Bed after Dredging
(8538.H.)

FIGS. 8, 9 AND 10. SECTIONS SHOWING EXTENT OF DREDGING REQUIRED FOR BERTH.



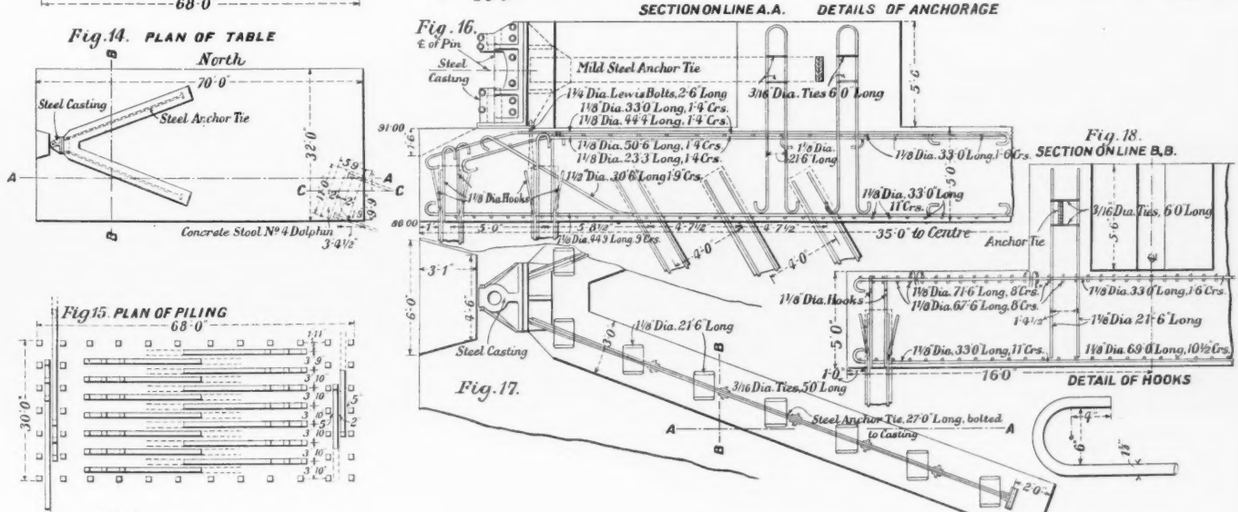


Fig.14. PLAN OF TABLE
North
70·0"
Steel Casting
Steel Anchor Tie
Concrete Stool No 4 Dolphin
SECTION ON LINE A.A. DETAILS OF ANCHORAGE
Fig. 16.
℄ of Pin
Steel Casting
Mild Steel Anchor Tie
1¼ Dia. Lewis Bolts, 2·6 Long
1⅛ Dia. 33·0 Long, 14 Crs.
1⅛ Dia. 44·4 Long, 14 Crs.
3/16 Dia. Ties 6·0 Long
1⅛ Dia. 50·6 Long, 14 Crs.
1⅛ Dia. 23·3 Long, 14 Crs.
1½ Dia. 30·6 Long 19 Crs.
1⅛ Dia. Hooks
1⅛ Dia. 21·6 Long
1⅛ Dia. 33·0 Long, 66 Crs.
1⅛ Dia. 33·0 Long 11 Crs.
35·0" to Centre
Anchor Tie
Fig. 18. SECTION ON LINE B.B.
3/16 Dia. Ties, 6·0 Long
1⅛ Dia. 71·6 Long, 8 Crs.
1⅛ Dia. 67·6 Long, 8 Crs.
1⅛ Dia. 33·0 Long, 16 Crs.
1⅛ Dia. 21·6 Long
1⅛ Dia. 33·0 Long, 11 Crs.
1⅛ Dia. 69·0 Long, 10½ Crs.
DETAIL OF HOOKS
Fig.15. PLAN OF PILING
68·0"
30·0"
Fig. 17.
Steel Casting
3/16 Dia. Ties, 5·0 Long
Steel Anchor Tie, 27·0 Long, bolted to Casting
(8538 I)

FIGS. 11 TO 21. DETAILS OF MOORING DOLPHINS.

THE GREAT LAKE HYDRO-ELECTRIC SCHEME, TASMANIA.

MR. J. H. BUTTERS, M.I.E.E., CHIEF ENGINEER AND GENERAL MANAGER, HYDRO-ELECTRIC DEPARTMENT OF TASMANIA, ENGINEER.

(*For Description, see Page* 792.)

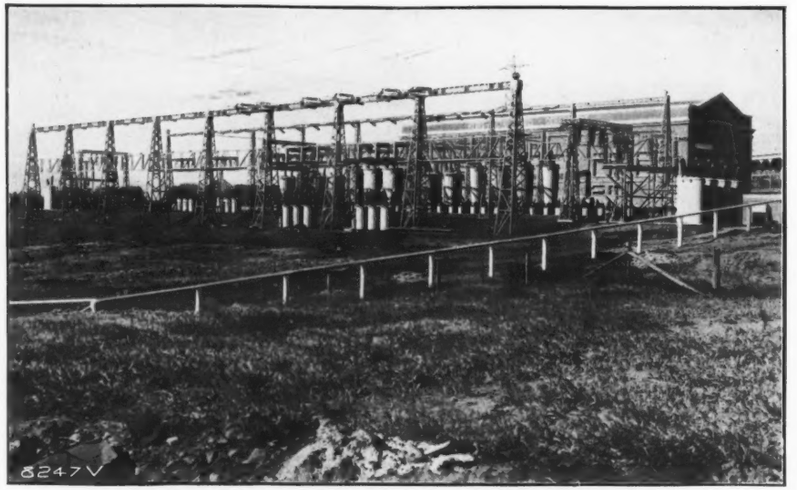


FIG. 79. RISDON SUBSTATION FOR THE HOBART DISTRICT.

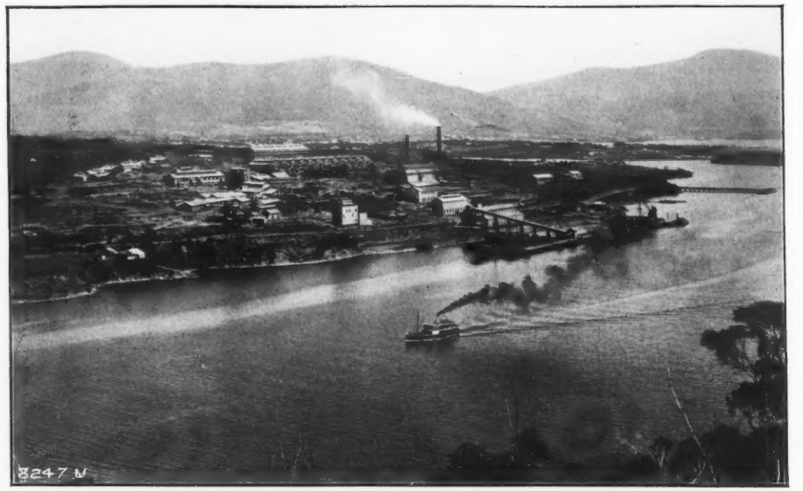


FIG. 81. WORKS OF THE ELECTROLYTIC ZINC COMPANY OF AUSTRALASIA, LIMITED, RISDON.

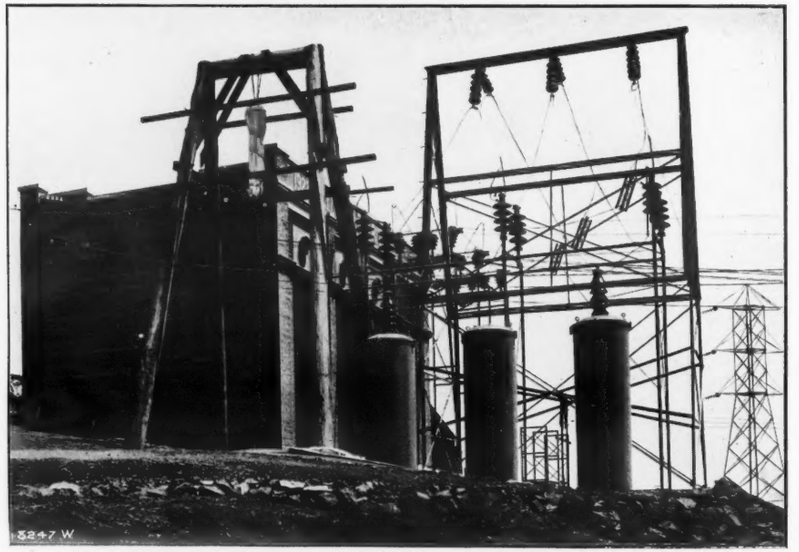


FIG. 80. LAUNCESTON SUBSTATION.

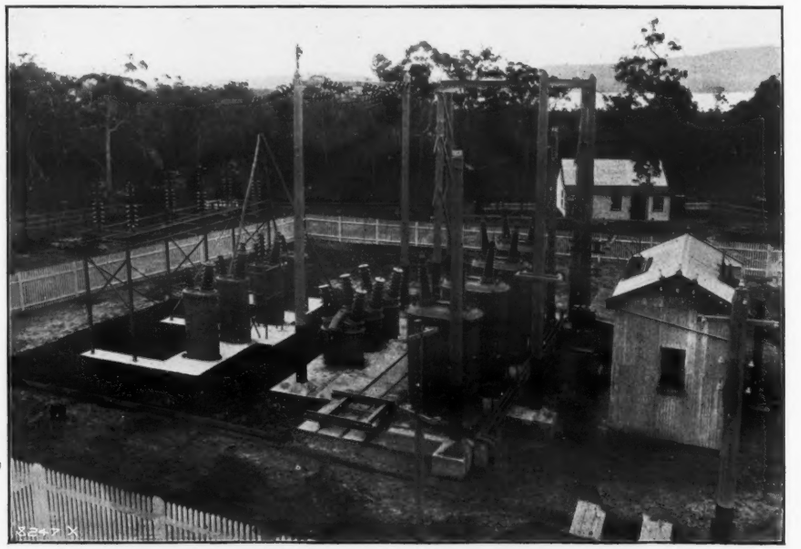


FIG. 82. ELECTRONA SUBSTATION WITH TEMPORARY EQUIPMENT.

(*To face page* 791.)

provided in the form of a hinged bridge leading to the upper deck. This bridge, which is indicated in Fig. 8, has a universal joint at each end, and at the lower end, is attached to a small carriage running on rails on the deck of the dolphin. These arrangements are, of course, necessary to allow for the movement of the dock in all directions relative to the dolphin. The fixed and hinged bridges and the boom gangway have been designed to carry a compact crowd of workmen, and, with the exception of the hinged bridge, can carry machinery parts, &c., up to 3 tons in weight. Heavy lifts will be handled by the 150-ton floating crane now in course of erection at Southampton. The dolphins and bridges were designed by, and constructed under, the supervision of Mr. Wentworth-Shields, the contractors for the dolphins being Messrs. A. Jackaman and Sons, Limited, Slough, and for the bridges Messrs. E. C. and J. Keay, Limited, Birmingham.

The arrangement of the dock itself can be followed by examining Figs. 1 and 2 on page 790 and Fig. 5 on Plate LXXIX. The main dimensions are also given on those illustrations so that they need not be repeated here, but we may mention that the total weight of the structure and equipment amounts to 18,800 tons. As will be seen, the dock is of the double-sided, self-docking type constructed in seven sections, any one of which can be lifted by the others for painting or repairs. Below the water line, the sections are connected by bolts passed through projecting angles, a joint chamber 5 ft. 3 in. wide being left between the sections; a rubber gasket is employed to make the joint watertight. Above the water line, the sections are joined by a plain cover plate secured by bolts. As shown in Fig. 1, the end sections are terminated by a non-buoyant platform, which can be removed for the self-docking of those sections, since the lengths would otherwise be too great to pass between the walls of the dock.

For pumping out the dock when lifting a ship, each section is provided with a pump on each side, so that there are 14 of these pumps in all. The pumps, which were constructed by Messrs. Worthington-Simpson, Limited, are of the centrifugal type with vertical spindles, and they are driven by Crompton electric motors mounted on the decks, each in a separate house. The pumps for the end sections have 15-in. outlets and are driven by 85-h.p. motors, while those for the central sections have 18-in. outlets and are driven by 113-h.p. motors. Another pump, with 12-in. connections and driven by an 85-h.p. motor, is provided for supplying circulating water to the auxiliary condensers of a ship raised in the dock. All the main pumps and the flooding valves, two of which are provided for each section, are controlled from a valve house located on the top deck, as shown in Figs. 1 and 2, and connected by telephone to all the motor houses and to the house in which the main switchboard is situated. In the valve house are two tables each about 20 ft. long, forming models of the dock divided into compartments, and each compartment is numbered to correspond with a plan of the dock hanging on the wall of the valve house. Each section of the table contains switches for operating the valves belonging to the corresponding section of the dock, and by the side of each switch is an indicator showing whether the valve is open or shut. There are also corresponding mercury columns indicating the depth of water in each compartment at any time, and it may be of interest to mention that over 4 miles of ⅜-in. piping were used for the connections to these columns. At one end of the valve house, gauges are provided to show the depth of water over the blocks at each corner of the dock, and hydrostatic gauges are also fitted for the purpose of indicating the trim and heel. Another similar hydrostatic gauge is provided to indicate the "breakage" of the dock, *i.e.*, the sagging or hogging of the whole structure, which must not be allowed to exceed 4 in. in ordinary working. The breakage can also be determined by an optical indicator comprising a telescope and fixed sights taking the full length of dock.

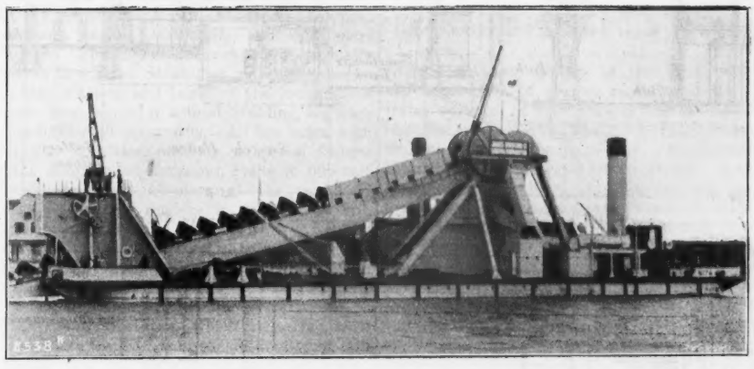


FIG. 22. BUCKET DREDGER "FOREMOST."

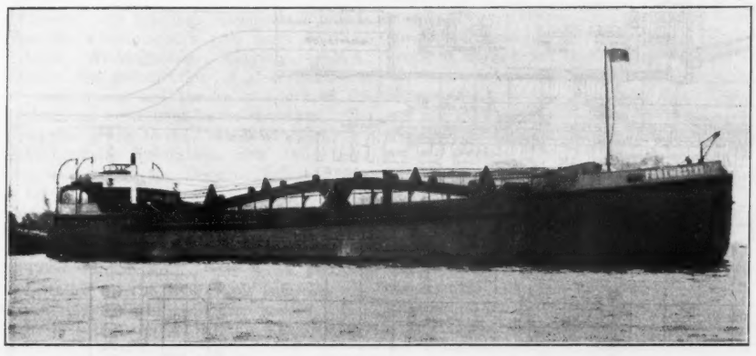


FIG. 23. STEAM HOPPER OF 1,000 TONS CAPACITY.

To facilitate the operation of centring a ship during the process of docking, four pairs of mechanical side shores, constructed by Messrs. Clarke, Chapman and Company, Limited, Gateshead-on-Tyne, are provided in the positions shown in Figs. 2 and 5. These shores consist of lattice-girder booms, 63 ft. in length and of rectangular cross section, having a rack on the lower side. By means of a pinion gearing with the rack and operated through reduction gearing by an electric motor, the shores can be moved longitudinally either inwards or outwards at two different speeds, and as the opposite shores are mechanically inter-connected so that each moves inwards or outwards to the same extent, the ship can be easily and accurately centred in this way. The shores can each exert a push of 10 tons, and a slipping clutch is provided in the gearing to limit the push to this amount. It should be explained that the function of the mechanical shores is that of centring only; they are not intended to hold the ship in position, the vessel being completely supported by the keel blocks and bilge blocks on the pontoon deck of the dock. In connection with the centring operation, we may mention that a block containing a number of electrical contacts is placed between the keel blocks where the ends of the keel of the ship will come, and the keel resting on these contacts lights lamps in the valve house to indicate the lateral position of the ship. This is necessary since the vessel may not be accurately centred by the mechanical shores, if she should enter the dock with some list.

Owing to the great weight to be supported on the keel blocks, which is of the order of 80 tons per foot run, special attention has been given to the design and arrangement of these components. The keel blocks are placed at intervals of 2 ft. 6 in. and, to distribute the load more uniformly, are mounted on three longitudinal oak baulks, 18 in. square in section, which run from end to end of the dock over the central bulkhead. Each keel block, of which there are 349 in all, consists of three superimposed cast-steel wedges which rest on the longitudinal baulks and are surmounted by a transverse oak block, 5 ft. 6 in. in length, and 11 in. square in section. On the latter is mounted a 3-in. soft-wood capping piece on which the keel of the vessel rests. The keel blocks are held in position by chains passed round a cleat on the upper wedge and attached to hook bolts on the longitudinal baulks. Any of the blocks can, however, be readily removed to give access to the keel of the ship by knocking out the wedges and releasing the chains. The bilge blocks, which are visible in Fig. 4, on Plate LXXVII, are of built-up construction, the lower portion being formed of steel plates and angles while the upper parts are of oak. Their positions on the pontoon deck can, of course, be arranged to suit the form of the ship being docked.

As clearly shown in Fig. 5, on Plate LXXIX, an electrically-operated travelling crane of the portal type is mounted on each wall of the dock for handling material on to or off from the ship. These cranes were constructed by Messrs. Ransomes and Rapier, Limited, and have a lifting capacity of 5 tons each. The length of their jibs is sufficient to reach to the centre line of the dock. As previously mentioned, a 150-ton floating crane will be available for heavy lifts. An unusual, but useful, feature of the design of the dock, also shown in Fig. 5, is the provision of gangways, 8 ft. wide on each side of the dock walls for the purpose of extending the working space on the upper decks. A pair of flying gangways of steel cantilever construction, are pivoted to the vertical and inclined faces of the walls at one end, as is most clearly shown in Fig. 4, on Plate LXXVII, to enable men to pass from one of the upper decks to the other when the pontoon deck is submerged.

As previously mentioned, the total lifting capacity of the dock is 60,000 tons, and, in accordance with the terms of the contract, the dock must lift a vessel displacing 52,500 tons on a mean draught of 32 ft. 9 in. within four hours. Trials will be carried out at the earliest possible moment, and their successful completion will mark an important stage in the development of the Port of Southampton, as well as in the progress of naval architecture as applied to the design of floating docks.

THE GREAT LAKE HYDRO-ELECTRIC SCHEME, TASMANIA.

(*Concluded from page* 694.)

THE largest and most important sub-station is that at Risdon. This is illustrated in Fig. 79 on Plate LXXXI, and Figs. 83 and 84, below. It receives power from Nos. 1 and 2 transmission lines and controlled. There are two banks, each comprising three 5,000 k.v.a. Westinghouse Company, U.S.A., transformers 88,000/11,000 volts, and two banks, each comprising three 1,333 k.v.a. General Electric Company, U.S.A., transformers, 88,000/6,600 volts. Provision is made in the design of all structures for the addition of two more 15,000 k.v.a. banks of transformers. The 88,000-volt bus is divided into Works is divided into two sections connected in parallel by disconnecting switches, and one half of the feeders are connected to each section, so that trouble on one section will not cause a complete failure of the supply. Current transformers are so placed as to measure the sum of the output delivered to all the 11,000-volt feeders and also that delivered to the Zinc Works feeders. Power is supplied from

Fig. 83.

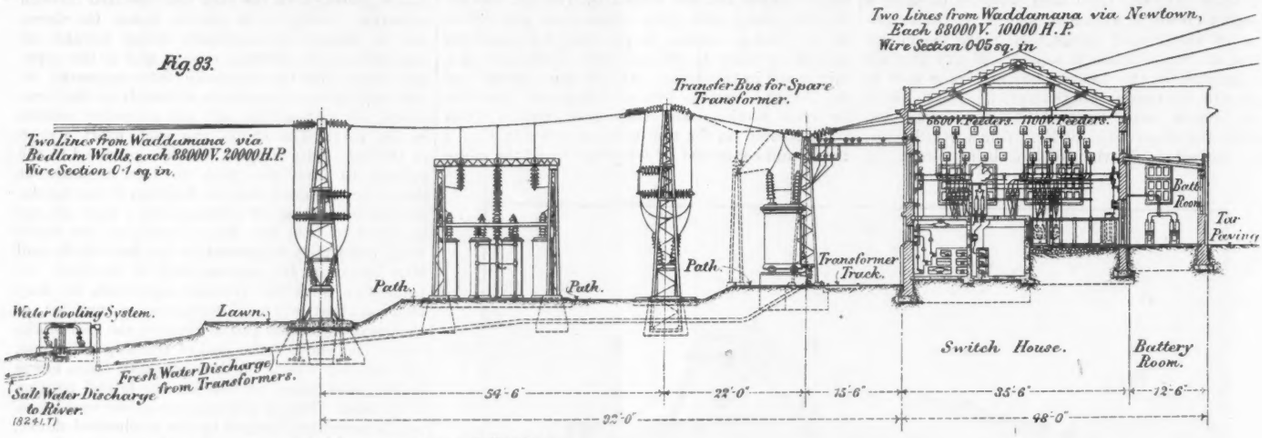
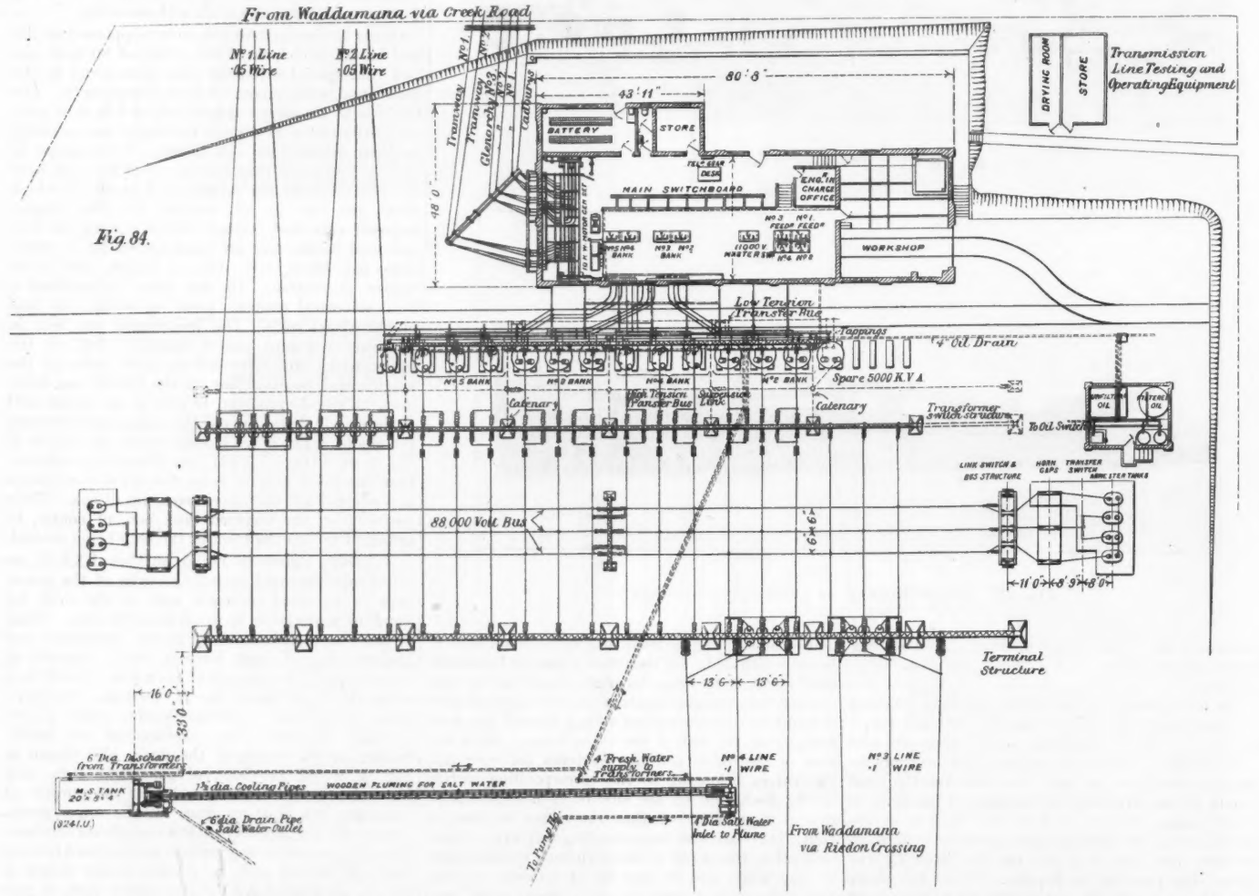


Fig. 84.



supplies Hobart and district. It is situated on the bank of the River Derwent close to the works of the Electrolytic Zinc Company. The whole of the transformers and 88,000-volt equipment are situated outdoor, the general layout and design of the structures being similar to that of the outdoor portion of the Waddamana plant already described. The low tension apparatus is housed in a brick building, the bus bars being enclosed in a reinforced concrete structure similar to that employed in the switch gallery at Waddamana. The control board is of the vertical type and all oil switches are remote two sections by a disconnecting switch, and one transmission line supplies each section. One bank of 11,000-volt and one of 6,600-volt transformers are also connected to each section, so that in the event of a failure occurring on one section of the bus, it is still possible to supply both 11,000 and 6,600-volt buses from one transmission line.

Power is supplied from the 11,000-volt bus bars to the Electrolytic Zinc Works, to the factory of Messrs. Cadbury, Fry and Pascall, at Claremont, and to certain portions of the Hobart district. The portion of the 11,000-volt bus supplying the Zinc the 6,600-volt bus to the Tramway Substation. Special features of the Risdon Station are the use of salt water, pumped from the Derwent, for cooling the transformers, and the adoption of oxide film lightning arresters connected to the 11,000 volt and 6,600-volt busses.

With regard to the cooling of the transformers it may be recorded that originally the transformers were provided with copper-cooling coils to enable sea water to be used direct. After nine months continuous operation, however, one of the coils failed from corrosion, a pinhole allowing water to enter

the transformer. A spare transformer was immediately substituted, but the failure was followed rapidly by the breakdown of others from a similar cause. As copper coils could not be procured at once, lead coils made by the Electrolytic Zinc Company were temporarily fitted, but these resulted in an unexpected amount of sludging, necessitating continuous filtering of the oil until the copper coils were replaced. The corrosion experienced appears to have been traced to the use of sea water, and the cooling system, shown in Figs. 83 and 84 has now been adopted in order to avoid passing salt water through the transformer coils themselves. In the new system fresh water is circulated in these coils, being in turn cooled by being passed through pipes laid in a salt water flume, in which a flow of sea-water is maintained by pumping.

The Launceston Substation, shown in Fig. 80, Plate LXXXI, is equipped with one bank of three 1,666 k.v.a. Westinghouse Company, U.S.A., transformers, 88,000/6,600 volts, and one spare transformer. These transformers were originally installed in New Town Substation, now converted to a switching station, and being of the indoor type they have been housed in a brick building, together with the 6,600-volt apparatus. All the extra high tension gear is placed outdoor, a special feature being the adoption of Ferguson, Pailin 88,000-volt air break switches, in place of the usual oil switches. A trolley renders it possible to run any transformer under a timber gantry for the purpose of hoisting out the core, or to substitute one transformer for another rapidly. This station supplies power in bulk to the Launceston City Corporation, which undertakes the distribution.

The Electrona Substation, which is clearly shown in Fig. 82, Plate LXXXI, is of the outdoor type, and is equipped with one bank of three 1,333 k.v.a., Westinghouse Company, U.S.A., transformers 88,000/6,600 volts. This station was a war-time installation and the overhead equipment is supported on wood poles and the 6,600-volt apparatus housed in a galvanised iron building. Designs are now in hand for the addition of a new bank of three 1,666 k.v.a. Westinghouse Company, U.S.A., transformers, the substitution of steel structures for the wood poles, and the replacement of the existing building by a steel frame structure. The station supplies power to the Carbide Works.

The Bridgewater Substation, now under construction, will supply the Derwent Valley Transmission Line. It will be an outdoor station arranged to receive power from either circuit of No. 1 Waddamana—Risdon Line. It will be equipped with one 1,000 k.v.a. three-phase transformer, 88,000/11,000 volts. Outdoor air break switches will be installed on the 88,000-volt side, but the 11,000-volt switch gear will be housed. This equipment is being supplied by the Metropolitan-Vickers Electrical Company, of Manchester.

Prior to the supply of power from the hydro-electric system, the metropolitan area was supplied by the Hobart Gas Company from a steam plant. The Hobart City Corporation also operated a D.C. steam plant to supply power to the Municipal Tramways, in addition to which it supplied D.C. current to private consumers within a small area. Towards the end of 1915 the Government of Tasmania purchased the rights and plant of the Hobart Gas Company, and undertook the retail supply of current to the city, the distribution system being 2,200 volts three-phase. In 1916 power was supplied from the Hydro-Electric Departments System at 6,600 volts to the Tramway power house, at which rotary converters had been installed. The network of the city and suburbs was extended gradually, power being fed at 6,600 volts., through a switching station at the Tramway plant, to transformer stations located at convenient points about the city. The larger of these transformers were housed in small brick buildings, but the others are carried on overhead platforms or hung on poles. They supply current at 415 and 240 volts. The 2,200-volt system of the Gas Company has been gradually replaced by the 6,600-volt system, and it will shortly be entirely eliminated. The 6,600-volt lines to the Tramway Substation are now supplied from Risdon Substation, and an 11,000-volt line is being added to supply additional converter units for the tramways. Some of the outer suburbs will also be supplied direct from Risdon at 11,000 volts, which will be transformed down to 415 and 240 volts.

The table below shows the growth of the Hydro-Electric Department's retail business since 1915, which was the last year of operation by the Hobart Gas Company. The great increase in the past two years is very noticeable.

Retail Supply Records, Hobart District.

Year ending June 30.	Consumers connected.	H.P. of A.C. Motors	Equivalent 30-watt lamps.	K.W. connected.	Units sold.	Maximum load in K. W.
1915	1,305	619	49,003	1,935	964,000	640
1916	1,999	784	59,420	2,369	1,152,387	800
1917	2,460	1,201	102,659	3,901	1,734,000	1,300
1918	3,066	1,358	127,646	4,843	2,456,000	1,450
1919	3,601	1,450	146,091	5,464	3,227,000	1,650
1920	4,888	1,682	194,504	7,090	3,752,000	2,385
1921	6,284	2,230	256,720	9,365	4,713,444	3,125
1922	7,603	2,669	325,407	11,753	6,076,977	3,125
1923	8,979	3,733	412,539	15,161	7,737,292	3,840

An interesting feature of the retail supply is the application of electric power to domestic hot water systems, of which about 200 have now been installed. These water heaters operate continuously and can, therefore, be supplied at a much lower rate than applies to ordinary domestic power. A number of electric cookers have also been installed, but their first cost at present retards their general adoption.

By far the most important gain which the State has obtained from the construction of the hydro-electric system, is the great expansion in the industrial life of the community resulting from the availability of ample power at reasonable rates, and the consequent increase in employment offered by the newly established industries. Among the important industrial works attracted to Tasmania may be mentioned the following:—The Electrolytic Zinc Company, of Australasia, Limited, whose large plant, shown in Fig. 81, Plate LXXXI, at Risdon, is capable of producing 120 tons per day of practically pure zinc from materials which were previously sent outside of Australia for treatment; the Carbide Works of Carbide and Electro-Products, Limited, at Electrona, on North West Bay; the factory of Messrs. Cadbury, Fry and Pascall, at Claremont; and the works of the Waterloo Chemical Company, at Hobart. At Launceston there are the woollen mills of Messrs. Paton and Baldwin, and the spinning mills of Messrs. Kelsall and Kemp. These industries represent a capital investment of between three and one-half and four millions of pounds, and will be followed by other large works. The indirect benefit accruing to the State as a result of the establishment of these industries more than justifies the expenditure on the hydro-electric scheme. The Electrolytic Zinc Company is now putting down large works for the manufacture of super-phosphates and there are prospects of other industries being established.

In order to gain the necessary information to enable further demands for power to be economically supplied, the Hydro-Electric Department has, for the last few years, been carrying out a hydro-metric and water power survey of the State. Regular gauging is now being made to determine the discharges of those streams which are likely to be used in future for power, irrigation or water supply. About 70 gauging stations are now being maintained and others are gradually being added. At the majority of the stations current meter observations are made by wading shallow streams or from bridges in the case of larger streams. Where a bridge does not happen to be available, a cage travelling on a steel cable is installed. In most cases the services of a local resident can be obtained to keep regular records of the stream height as indicated on a gauge staff. In some cases, on canals and streams particularly liable to frequent and rapid changes of level, automatic water level recorders, drawing a continuous chart and operating for one week without attention, are employed. In a few cases, stations are located in uninhabited areas in the mountains and in such instances, automatic water level recorders, which run without attention for four months, are installed. These machines print the time and gauge height on a continuous strip of paper at intervals of a quarter of an hour.

In conjunction with the stream gauging, surveys are being conducted of the principal lakes and streams for the purpose of determining suitable power sites and storages, and a number of economically feasible power developments have already been worked out. Some of these schemes are indicated on the map Fig. 1 (page 355 *ante*). The Shannon scheme will utilise the discharge from the Great Lake before it reaches the headworks of the existing Waddamana canal, and 13,000 h.p. can be developed. Below Waddamana the water can be used a third time by the Lower Ouse Scheme, having an estimated capacity of 50,000 h.p. The tail race of this development will be 1,000 ft. above sea level, and the Ousedale Scheme, not yet completely worked out, will provide a fourth utilization of the water stored in the Great Lake.

Lake St. Clair, if dammed at the outlet, will provide large storage, the water from which can be utilised in two developments on the Upper Derwent River, having a combined capacity of about 60,000 h.p., which can be still further increased by the construction of a large dam on the Derwent about ten miles below Lake St. Clair.

By means of large dams on the King and Huon Rivers, 65,000 and 20,000 h.p. respectively can be developed. Another large block of power can be utilised on the Florentine River, but the extent to which storage can be developed has not yet been fully investigated. The Arthur's Lakes, Chudleigh Lakes, and Lake Rolleston represent high head schemes with comparatively small storages, and the estimated capacities are 11,000, 25,000 and 25,000 h.p. respectively. A number of minor schemes have been investigated, but those enumerated above can provide an additional capacity of over a quarter of a million horse-power, which can be delivered at any point in the State.

In concluding this description of the Great Lake Scheme we wish to acknowledge our indebtedness to Mr. J. H. Butters, C.M.G., the Chief Engineer and General Manager of the Hydro-Electric Department, for courteously placing at our disposal such complete information regarding the undertaking.

THE COLLIERY AT THE BRITISH EMPIRE EXHIBITION.

(*Continued from page* 759.)

ELECTRICAL EQUIPMENT.

THE Power Station of the British Empire Exhibition has been described in ENGINEERING in a series of articles which commenced on March 14 (pages 330, 363, 387, 425, 455, and 490). Three-phase current from this station at 3,300 volts and 50 cycles is supplied direct to the engine room and through the transformer room to subsidiary plant at the colliery. The conditions are therefore very similar to those which would exist in a colliery equipped with its own generating station or adjacent to a large supply station.

On page 677 we have already briefly mentioned the winding engine, and that the winding motor is arranged for reverse current braking. The general scheme of the switches, transformers, contactors, and auxiliary appliances is shown in Fig. 59, page 794. The main motor for the winder, with the control switchgear, liquid controller and auxiliaries, are by the British Thomson-Houston Company, Limited, of Rugby.

Connection is made to the electric supply by means of a triple-pole oil-break incoming main switch of the ironclad draw-out pedestal type, of substantial design suited to mining work. The switch is provided with trips which will throw it open in the event either of overload or of failure of the electric supply. An auxiliary triple-pole oil-break switch passes current to a step-down transformer, which provides a supply at 550 volts for a three-phase brake solenoid and for the 10-h.p. motor driving the small air compressor. The air-compressor motor is started and stopped automatically by means of contactor gear fitted with an air-pressure governor; this causes the contactor gear to start or stop the motor as the pressure falls or rises according to the demand.

The 500-h.p. winder motor, Fig. 60, is controlled from the driver's platform by means of a hand lever which has three functions; it operates: (1) a master-controller actuating magnetically-

operated, high-tension air-break switches of the contactor type for the stator current, to give either forward or reverse rotation to the motor; (2) interlocking contacts for completing the various safety and interlocking circuits, these contacts being incorporated in the master-controller; and (3) a controller of the liquid type for the rotor circuits.

A front view of the stator-contactor gear is shown in Fig. 63, on page 798, and the back view in Fig. 64, from which it will be seen that the contactors are carried on a steel-pipe frame in a simple and secure manner, without slate or other insulating panels. An effective arrangement of mechanical and electrical interlocking is provided between the forward and the reverse contactors, so that it is impossible for either to close before the complete rupture of the arc at the tips of the other.

The emergency and indicating arrangements provided are very complete and effective. Red and green indicating lamps are mounted on the driver's instrument pedestal; the green lamp indicates when the 3,300-volt supply is available on the reversing contactors, the red lamp lights up if the driver should start in the wrong direction at the commencement of a wind. Limit switches are provided in the head gear for completing this red lamp circuit and also for action in the event of over-winding. Should an overwind occur, the supply circuit is broken and the emergency brakes are applied. Special provision is made to enable the winder to be "backed out" after an overwind. These arrangements are such that whereas the driver can "back out," it is rendered impossible for him to move the over-wound cage further into the head-gear.

Liquid Controller.

The liquid controller shown in Fig. 65 on page 798, consists of a steel tank in which are carried a frame (Fig. 66), supporting three "pots," three fixed electrodes and three moving electrodes, shown in their outer position, and a cooler (Fig. 61, page 795) in two sections mounted on an angle iron framework. Each fixed electrode is carried at the end of an insulated rod inside a "pot"; the other end of the rod is connected to one of the main terminals in the winding box. The pots and rods are of steel and are covered with a special moulded insulating compound which is non-brittle, unaffected by the electrolyte even when hot, and has a high insulating value. This form of construction minimises the trouble due to breakage that is common with porcelain pots, and to the warping and splitting that occur with wooden pots. Between the side walls of each pot are fixed baffles that are interrupted in the middle so as to leave a space which forms the passage for the moving electrode and for the current that flows in the electrolyte between the moving and fixed electrodes, the latter being located at the closed end of the passage. The baffles prevent the main current from straying from the direct path between the electrodes, and guide the heated electrolyte which circulates upwards through the "pots" and downwards through the cooler which is immediately outside the pots. The arrangement is such that when the main current paths through the electrolyte are lengthened no alternative paths are shortened. It is necessary that the movement of the electrodes shall take place from the "full-out" to the "full-in" position each time the motor is started, irrespective of the direction of movement of the driver's hand-lever which gives positive control when pushed either forward or backward according to the required direction of rotation of the motor. This result is obtained by arranging that the roller at the end of the vertical operating rod (hidden at the back in Fig. 65) shall occupy a central position in the cam plate when the electrodes are in the "full-out" position. Movement in either direction depresses the roller and brings the electrodes to the "full-in" position. Furthermore, the slot in the cam plate is so shaped that for any particular movement of the driver's lever the corresponding movement of the electrodes will give a practically proportionate resistance in the rotor circuit. The large ratio between the maximum and minimum resistances of the controller render it extremely suitable for reverse current braking. The electrolyte is a solution of washing soda, and, when of normal strength, the minimum resistance is such that the natural slip of the induction motor (with short-circuited slip-rings) is increased by less than 1 per cent.

The moving electrodes are carried on arms connected to a common cross rod, which is held by two outside supporting rods attached to a horizontal shaft at the top of the controller. The shaft is mounted in ball bearings so that the whole system can swing freely like a pendulum, the motion of the moving electrodes being in a curved path towards the stationary electrodes. In order to balance the moving system, a spring device (shown in Fig. 65) is provided. This gives a practically perfect balance, and at the same time keeps the inertia of the balancing system negligible. The operating shaft has an extension at both ends, so that the lever gear and spring balancing arrangement can be mounted on either side.

Fig. 65 also shows the arrangements for ensuring interchangeability. The electrode "pots," stationary electrodes, and moving system, being attached to a top supporting frame, can be withdrawn from the tank as one unit. When it is required to do this, the moving electrodes are moved to the innermost position and held there by a small locking piece on the spring arm shown in Fig. 65. The cooler (Fig. 61) is also arranged as a complete unit, and can be lifted out of the tank after removing the pipe connections. The cooling water circulates through the tubes, entering at the lower tubes of the bottom portion and leaving from the top tubes of the upper section. One end of each cooler section is fixed rigidly, and the other end is supported so as to allow expansion and contraction to take place freely.

The rotor connections are brought into the terminal box seen in Fig. 65, which will take either one or two trifurcating boxes as may be found necessary, or, by means of separate cover plates, the cables may be led in through pipe conduit or through plain bushes. On test, the controller was

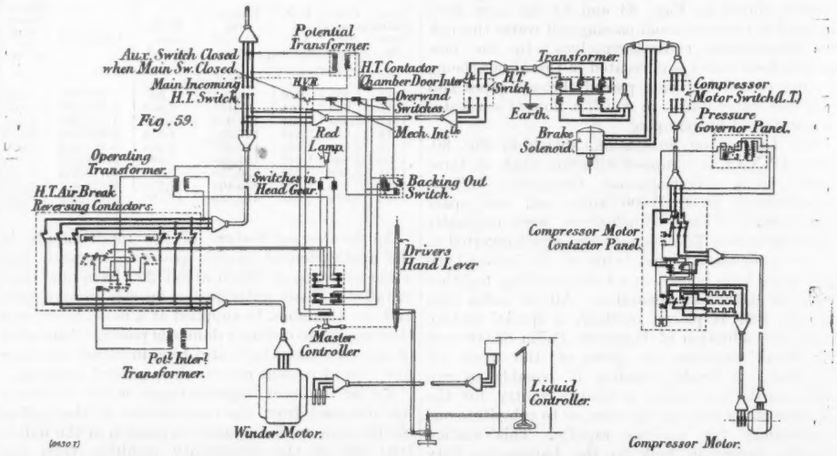


FIG. 59. WIRING DIAGRAM FOR ENGINE HOUSE.

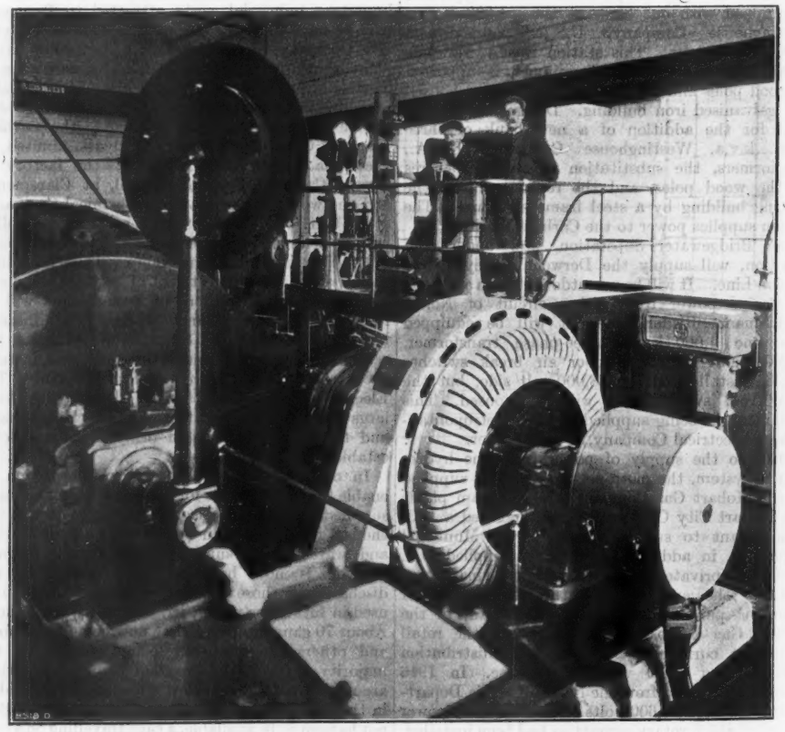


FIG. 60. WINDING ENGINE MOTOR AND REDUCTION GEAR.

found capable of dissipating 400 kw. continuously, the ratio of maximum to minimum resistance was of the order of 400 to 1, and the force required at the driver's handle to operate the controller, including the master controller, was about 10 lb. when the full range of the controller was covered in 5 seconds. A current of a value of 1,000 amperes was easily carried, and it was evident that considerably larger currents could be carried if desired. Voltages of the order of 3,300 volts alternating current were applied across the terminals of the controller when filled with electrolyte under normal working conditions, and considerably higher voltages could obviously have been used. It was necessary to apply a tension of 32,000 volts to the insulating compound before a breakdown occurred.

Motors.

Besides the winding motor, there is a 10 h.p. motor driving the Alley and MacLellan air compressor in the engine room; this is shown in Fig. 62. A 10 h.p. protected type slip-ring induction motor running at 940 revolutions per minute, drives a Gwynnes pump in the washery plant. This motor is fitted with a rotor starter and oil switch with time-lags, low voltage release, ammeter and cable box. There is a duplicate of this set in the washery and also a 25 h.p. motor to run at 710 revolutions per minute of similar construction, but fitted with a belt pulley for driving mechanical parts of the gear. All of these motors are made by the British Thomson-Houston Company Limited, and are fitted with mining type slip-ring covers and stator and rotor trifurcating boxes.

For driving the Walker air compressor for the mine supply, there is a slip-ring induction motor constructed at the English Electric Company's Phœnix Works, Bradford, of 186 h.p., taking three-phase current at 440 volts, 50 cycles, and running at 600 revolutions per minute. It is controlled through a switch pillar of the standard SXB type of the English Electric Company arranged for floor fixing and fitted with an oil switch, having three overload releases and an ammeter; the starter is of the English Electric type. This motor drives through a David Brown single reduction gear with a flexible coupling between the motor and the first motion shaft.

In order to improve the low power factor of the system this set has been supplemented with an oscillating phase advancer supplied with direct current from a small motor-generator set operated from the three-phase 440 volt supply. We hope later to give a brief description of this phase advancer.

Above ground there are four motors constructed by Messrs. E. Brook, Limited, of Huddersfield, using the three-phase, 440 volt, 50-cycle, current. One of these, of 20 horse-power, drives the pneumatic hammer in the workshop; two others, each of 20 horse-power, drive the Marcus screens, and at the bottom of the mine there is a 30 horse-power motor running at 720 revolutions per minute, for driving the Markham continuous rope haulage gear; another of 5 h.p. drives the tipplers. These motors are of a specially robust design for use in mines and are made explosion- and flame proof. The yoke of the machine is in one casting, bored throughout its entire length to receive the stator stampings. Radiation surface is provided on the exterior by rounded ribs, and, in order to avoid air pockets underneath the motor, the ribs are carried down to the foot with a channel through between each pair.

The yoke is machined on its two side faces, forming substantial spigots that provide positive location for the end shield brackets and give a face in excess of the 2 in. required by the Home Office regulations. The trifurcating boxes are cast half in the yoke and half in a loose cover; an inspection cover is fitted independently on the box, and a gland is provided to receive the armoured cable. Gas plugs are fitted at the highest and lowest points of the cavity to enable it to be run up with compound. The motor end shields are of radial ribbed design with a very rigid bolt flange; each is machined to ride on the yoke spigots and is faced and bored to receive ball or roller bearings; the former are used at the slip-ring end, and a roller bearing of great overload capacity is fitted at the shaft extension end. The location and protection of the bearings is made by heavy caps. The air sealing is secured by making these of as great a length as possible and boring them 0·003 in. larger than the shaft diameter; the cap being made a tight fit in the spigot, the clearance round the shaft after assembly is only 0·0015 in., a limit which has proved effective in practice in cooling the hot gases before they can reach the external air.

The rotor is built on a cast-iron spider and fixed in position by malleable end rings. Inspection ports are fitted in the motor end shields for checking the radial air gap. The motors are of the outboard slip ring type; the cables are brought from the rotor windings through the centre of the shaft, sealed at the outer end, whence they spread to the slip-ring terminals. All joints of the operating gear that lead outwards are made of very exceptional length. The design of the slip-ring cap and cover is in conformity with the rest of the machine, which is designed to stand an internal explosion pressure of 100 lb. per sq. in.

There are two of the well-known General Electric Company's motors on the three-phase, 440-volt, 50-cycle supply; the one is a 45 h.p. Witton slip-ring motor with G.E.C. draw-out mining type pillar and flame-proof rotor starter for controlling the motor which is used for driving the Pearn three-thrown pump. The other is a 25 h.p. Witton, three-phase, squirrel-cage motor with draw-out star-delta starter.

The Sirocco ventilating fan is driven by an 8/10 h.p. motor constructed by Messrs. Electromotors, Limited, of Openshaw. The Holden and Brooke six-stage turbine pump is fitted with a three-phase motor of about 160 h.p.; some of the coal cutters are constructed with motors of 20 to 35 h.p. each, and some of the conveyors also are driven by attached electric motors. The aggregate of the power supply is over 1,200 h.p., and the conditions cover the whole range from the steady and continuous drive of the pump and ventilating fan, to the intermittent work of the winding engine with its sequences of reversal of load and of direction of rotation.

(To be continued.)

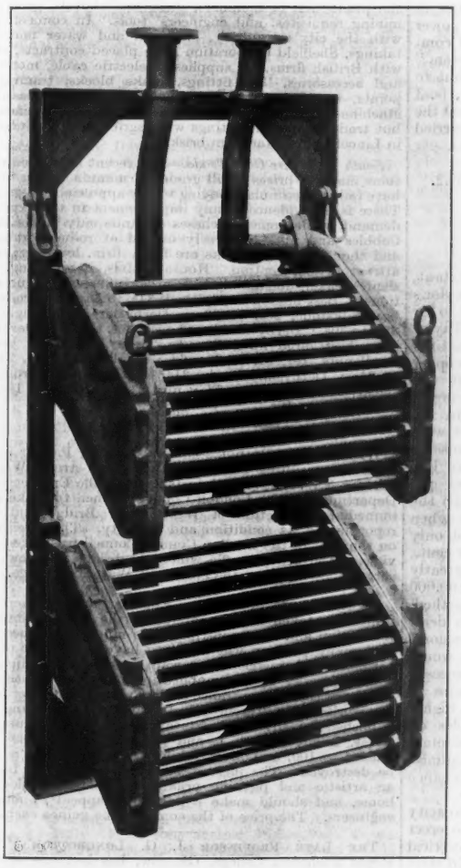


Fig. 61. Cooler for Liquid Controller.

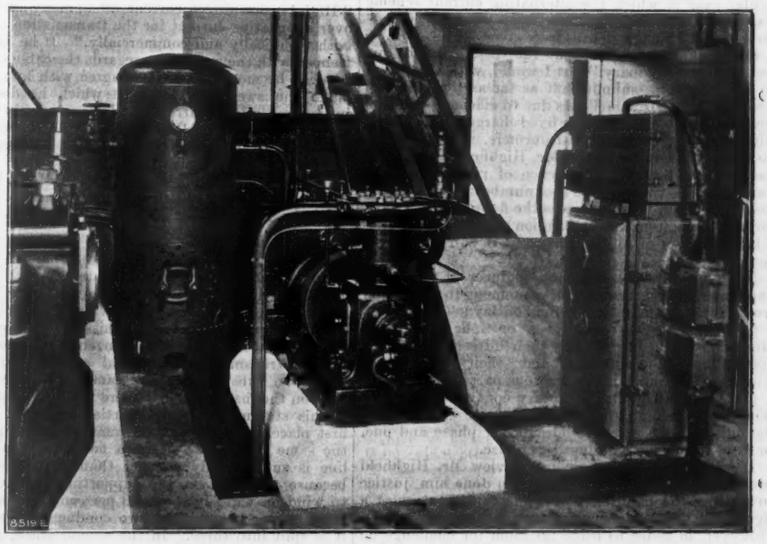


Fig. 62. Electrically-driven Air Compressor.

Canadian Metal and Mineral Trade.—Canada exported during the twelve months ended March 31 last, iron and iron products valued at 66,975,571 dols., compared with the previous year's total of 51,137,912 dols. Exports of non-ferrous metals from the Dominion during the same period reached a total value of 65,911,171 dols. as compared with 44,358,037 dols. for the year 1922–23. Exports from Canada of non-metallic minerals during the year ended March 31 last, amounted in value to 26,776,330 dols., as against 27,646,704 dols., the total for the previous twelve months. They included asbestos, 228,016 tons, value 8,678,164 dols., and coal 1,217,835 tons, value 7,842,259 dols. Coal imports during the twelve months included 4,849,372 tons of anthracite, worth 44,005,106 dols., and 15,637,812 tons of bituminous, valued at 44,382,011 dols. Coal imports into Canada from the United Kingdom during the year included 205,848 tons of anthracite, worth 2,070,865 dols., and 269,871 tons of bituminous, valued at 1,127,406.

LETTERS TO THE EDITOR.

"THE TRANSVERTER."

TO THE EDITOR OF ENGINEERING.

SIR,—Mr. W. E. Highfield's letter in your issue of the 6th instant has been brought to my notice, and as I think there are statements therein which are apparently made under a misapprehension, which if left unnoticed will create a wrong impression, I beg leave to draw upon the hospitality of your columns. Mr. Highfield has, perhaps unintentionally, quite diverted attention from that which was the real point of my letter in your issue of May 16. I stated quite definitely in that letter that I was considering the question of transmission of power in large bulk, the implication being for general purposes, and the only reason which I had for referring at all to Mr. Roger Smith's paper of a year and a-half ago was to fix the size of unit to be considered.

It is quite beside the point to introduce figures of 730,000*l.* and 355,000*l.*, which were got out for a particular case in which the alternating current scheme was handicapped by the employment of rotary converters, and of which no details were given.

Mr. Highfield suggests that the costs given by me are purely "imaginary," but I would, with all respect to Mr. Highfield, submit that as far as the first two items at least, viz., the losses due to efficiency and the costs of attendance and other fixed charges as compared with that of pure static transformers, my figures are no more "imaginary" than Mr. Highfield's own. He has not yet had the experience of running a large number of his transverters in a number of substations for a number of years, whereas the figure which I gave for my second item was based upon the costs of running a large number of rotary converters in substations for such periods.

Now, I think no substation engineer of any large experience would hesitate for a moment to say which would involve the greater annual outlay:—

(1) The cost of, say, three or four 2,000 kw. Highfield transverters with their fifteen to twenty 100,000-volt commutators and their transformer windings broken up into numerous parts, or

(2) An equal number of rotary converters of equal power with their correspondingly large transformers having only one magnetic circuit per phase and one, or two, secondary windings per phase.

I think that from this point of view Mr. Highfield must concede that I have *more* than done him justice in putting the maintenance of his commutators at a figure only a little higher than that for rotary converters. However, in order to leave no room for challenge on this score, I will reduce the figure to the same as that for rotary converters. Again, in dealing with the generating station end of the line, I only took *half* the rate taken for the substations, which was really quite unduly liberal. As regards the question of losses due to efficiency, I am prepared to agree that with really large transverters at the generating end the overall efficiency will probably not be more than 5 per cent. lower than with transformers, instead of the 6 per cent. which I took in my earlier letter.

Now, as regards the last two items of my letter to ENGINEERING of May 16, I was, of course, obliged to make somewhat of a guess, and I assumed what seemed quite reasonable at the time, viz., that the capital outlay of the transverter, with its very heavy commutator expense, would be much the same as that of a rotary converter, particularly in view of the fact that the transverter was a patented article and that no doubt Messrs. The English Electric Company intended to make a good profit upon it in consequence.

Again, to be safe, I am prepared to assume that the transverter, including its transformers, will cost only 2*l.* per kw. more than would be the case with large static transformers, and as regard maintenance we have what virtually amounts to six times the number of transformers and 18 times the number of secondary windings that would ordinarily be employed for large power transmission work. I feel confident that transformer makers (apart from the English Electric Company) would, with one accord, agree that they could not *maintain* them for anything like the cost that they would a few large transformers. I happen to know something about the difficulties of maintaining even large transformers, at 30,000 volts; Mr. Highfield has perhaps yet to get the experience that, for example, the American makers of transformers went through at 100,000-volts before they settled down to stable designs. It is also a great draw-back in dismantling a transformer to have a very large number of high tension secondary-connecting wires; as will be readily granted by all transformer builders.

If Mr. Highfield is prepared to say that the selling price of the transverter, plus its transformers, will not be in excess of 2*l.* per kw. above the cost of large static transformers (without any rotary converters) all I can say is that I shall be very greatly surprised.

Summing up the various items in my letter above referred to, with the modifications I have discussed in the present letter, we have the following:—

	£
Efficiency losses (over and above those of static transformers)	195,000
Attendance and fixed charges (based on rotary converters)	270,000
Extra capital outlay (taking only 2*l.* per kw.)	90,000
Maintenance (taking only 2*l.* per kw., extra outlay)	180,000
Total capitalised sum	735,000

This is the sum which is available for buying cables for the alternating current scheme. The case which I cited was really hardly sufficiently representative of what we shall be doing in the very near future, when we shall no doubt be transmitting amounts of 50,000 to 100,000 kw., as they are now doing in numerous places in America.

In conclusion, I would like to hear what our American friends would say as to Mr. Highfield's dictum that: "High tension direct current offers many advantages over alternating current for the transmission of power both technically and commercially." If he had commenced with the words "as regards the cable system" I might be more prepared to agree with him, but to make the sweeping statement which he does, is, I suggest, entirely unwarranted. I have no doubt that the line from Boston to Washington will still be carried with static transformers and alternating currents.

Yours faithfully,
A. M. TAYLOR, Major S.O.2.

"Slade Lodge," Erdington, Birmingham.
June 17, 1924.

TO THE EDITOR OF ENGINEERING.

SIR,—I notice in your issue dated the 6th instant, that Mr. Highfield has not dealt with Major Taylor's letter which appeared in the previous number in so far as the latter referred to transmission. Major Taylor stated that comparing direct-current with alternating-current transmission, the total quantity of copper would be substantially the same, and that it was only on the insulators that there would be a saving.

This statement is only partially correct. In the first place, even if the total quantity of copper were the same in the two cases, a two-wire transmission line is substantially cheaper than a three-wire line because the load on the supporting structures due to wind on wires is about 20 per cent. less when the total copper is split into two conductors than when it is split into three. In the second place, not only are the insulators reduced in number by 33 per cent., but the cost of each individual insulator is greatly lessened. The insulation of a line working at 100,000 volts direct current with the centre point earthed, is a comparatively simple matter and can be dealt with by a pin insulator of quite ordinary dimensions. The corresponding alternating-current line would require a suspension insulator, and this again necessitates comparatively large clearances from wire to wire, and correspondingly larger crossarms and higher towers. Ninety-nine per cent. of the troubles on overhead lines are insulator troubles, and the elimination of one-third of the insulators would minimise interruptions and also the cost of both maintenance and operation.

A further point is that with lines of small capacity where it is necessary for mechanical reasons to erect a larger sized wire than is called for by purely electrical considerations, it may be possible to use a mild steel conductor instead of the more expensive metal.

Yours faithfully,
CHARLES W. KAY.

"Fairoak," Woking, June 18, 1924.

THE LATE MR. EDGAR PHILIP RATHBONE.—We regret to announce the death, which occurred on the 14th inst., at White Cross, Wallingford, of Mr. Edgar Philip Rathbone. Mr. Rathbone was one of the founders of the Institution of Mining and Metallurgy, of which he was a member of Council. He studied at the London School of Mines, and at Freiberg and Liége. For many years he acted as a mining consultant in North, Central and South America, and in Central Europe. At one time Mr. Rathbone was Chief Government Inspector of Mines on the Rand, where he assisted in the drafting of the mining regulations; he held that office at the time of the Jameson Raid. He was, also, head manager of the Salisbury mine, and founder of the firm of Bainbridge, Seymour and Co., Limited, mining engineers, Salisbury House, E.C. 2., in which he was a partner. It is interesting to add, as an illustration of the kindliness which animated Mr. Rathbone, that he introduced on the Rand the St. John Ambulance Association, of which he was a past president. He was also one of the founders of the Rand Pioneers. During the war Mr. Rathbone was a Government Inspector of Aeroplanes. At the time of his death he was 67 years old.

NOTES FROM SOUTH YORKSHIRE.

SHEFFIELD, Wednesday.

Iron and Steel.—Except in tools and implements, the market for steel products is not noticeably more active than a week ago. Despite a slight expansion in other districts, local iron and steel production continues on a restricted basis, and owing to the closing down of several furnaces in the South Yorkshire and Lincolnshire areas, it is expected that the official returns for last month will show a falling off as compared with April, when the aggregate was 9,000 tons below that for the corresponding month of last year. Price considerations constitute the main difficulty in renewing expiring contracts for common steels. The recent fall in fuel costs has not enabled makers to come forward with more attractive rates, as in many instances those rates were already unremunerative and represented an actual loss per ton of production. Pig-iron producers may be able to contract more favourable terms for coke supplies to blast furnaces now that the export demand has weakened. Quotations for bars are steadily maintained at last month's figures, owing mainly to the call on wagon-building account. The improvement in the demand from shipbuilders is reflected in the steadiness of the market for steel sheets. Railway furnishings represent an active section, and there is considerable activity in the production of hammers, picks and shovels, general mining requisites, and engineers' tools. In connection with the city's tramway, electrical and water undertakings, Sheffield Corporation have placed contracts, all with British firms, for supplies of electric cable, motors and accessories, 'bus fittings, brake blocks, tramway points, transformers and fuseboards, and car chassis. Machine-knife makers report a rather improved business, but trade in special castings with agricultural engineers in Lincolnshire is far from brisk.

South Yorkshire Coal Trade.—The recent heavy reductions made in prices of all grades of manufacturing fuel have failed to stimulate buying to any appreciable degree. There is no evidence of any improvement in the export demand, while home purchases continue only moderate. Cobbles and nuts are freely offered at reduced rates, and though washed slacks are fairly firm, lower grades attract little attention. House coal is, if anything, a shade weaker, due mainly to weather influences. Quotations:—Best branch handpicked, 34*s.* to 35*s.*; Barnsley best Silkstone, 28*s.* to 29*s.*; Derbyshire best brights, 28*s.* to 30*s.*; Derbyshire best house, 25*s.* to 27*s.*; Derbyshire best large nuts, 24*s.* to 25*s.*; Derbyshire best small nuts, 18*s.* 6*d.* to 20*s.* 6*d.*; Yorkshire hards, 23*s.* to 24*s.*; Derbyshire hards, 21*s.* 6*d.* to 23*s.* 6*d.*; rough slacks, 12*s.* 6*d.* to 15*s.* 6*d.*; nutty slacks, 12*s.* to 14*s.*; smalls, 8*s.* to 10*s.*

WESTMINSTER BRIDGE.—Messrs. Rendel, Palmer and Tritton, consulting engineers, Dartmouth-street, Westminster, S.W. 1, have been instructed by the Engineering Department of the London County Council to make an immediate inspection of Westminster Bridge and to report as to its condition and stability. This decision on the part of the London County Council was taken in view of the heavy traffic which the bridge has now to carry following upon the closing of Waterloo Bridge.

AN EXHIBITION SOUVENIR.—Engineers and engineering firms have taken such an interest in the British Empire Exhibition and have contributed so much to its success that many of them will desire to have a souvenir of a permanent character. This want has been met in an admirable way by the publication of a very pleasing etching of the main entrance to the Palace of Engineering, the work of Mr. Terence H. Lambert. The etching is published by Mr. W. J. Stacey, of 71, Great Russell-street, London, W.C. 1, and the number of copies is limited to 100, and after taking these the plate is to be destroyed. The picture, suitably framed, will form an artistic and pleasing ornament either for office or home, and should make a particular appeal to many engineers. The price of the copies is one guinea each.

THE LATE PROFESSOR J. G. LONGBOTTOM.—The Royal Technical College, Glasgow, has lost one of its most capable exponents of applied science by the sudden death of Professor John Gordon Longbottom, which occurred on June 6, after the performance of a very serious operation. Professor Longbottom, who was only 54 years of age at his death, was a Yorkshireman and received his early education in Keighley and at the Bradford Technical College. His apprenticeship was served in the works of Messrs. F. and J. Butterfield, Keighley. After winning a Whitworth Scholarship he became a student at the Royal College of Science, and University College, London. He went to Glasgow after he had had some experience of teaching under Professor Karl Pearson and eventually became Professor of Mechanics. He did excellent work in training the young engineers of Glasgow and will be remembered by them and by his colleagues in the work, as a man of great capacity who possessed a very kindly nature. Ever backward in pressing his claims to recognition in the wider spheres of his profession, his work was not heard of outside the College to the extent deserved, and he is thus only known by perhaps two of his contributions: the one on "The Stresses on the Rim and Arms of a Fly-wheel," given to the Institution of Engineers and Shipbuilders in Scotland in 1919, and the other a report of investigations, jointly undertaken with Professor Campion, on the effects of high temperatures on the strength characteristics of metals. Professor Longbottom was an Associate of the Royal College of Science a Member of the Institution of Mechanical Engineers, and a Member of the Institution of Engineers and Shipbuilders in Scotland.

NOTES FROM CLEVELAND AND THE NORTHERN COUNTIES.

MIDDLESBROUGH, Wednesday.

The Cleveland Iron Trade.—There is little new to report of the position as regards Cleveland pig-iron. Business continues within very narrow limits, and prospects are discouraging as the limited output is more than ample for current needs, and the situation is threatened with stocks accumulating once more. Continental customers are holding off, and home business is restricted to the purchase of small parcels for early requirements. Further fall in values is anticipated though producers protest that current rates are unremunerative. Whilst price concessions are obtainable, makers continue to ask 95*s.* for No. 1 quality; 90*s.* for No. 3 g.m.b.; 89*s.* for No. 4 foundry; and 88*s.* for No. 4 forge.

Hematite.—East Coast hematite is slow of sale and prices show downward tendency. In this branch also production is in excess of requirements and increasing stocks threaten to hamper the situation. Nos. 1, 2 and 3 are put at 97*s.* 6*d*; and No. 1 is quoted 6*d.* above mixed Nos.

Foreign Ore.—There is next to no new business passing in foreign ore, but imports against contracts made some little time ago are heavy. Consumers are well placed as regards supplies, and are not at all disposed to enter into negotiations for new contracts. Quotations are nominal and are based by sellers on best rubio at 23*s.* 6*d.* c.i.f. Tees.

Blast-furnace Coke.—Durham blastfurnace coke is a shade firmer, but sales are still few and small. Good medium qualities are 27*s.* 6*d.* to 28*s.*, delivered to local users.

Manufactured Iron and Steel.—There is little doing in finished iron and steel, and quotations for some descriptions may be reduced this week. At the time of writing, however, market rates still stand; Common iron bars 12*l.* 10*s.*; iron rivets, 14*l.* 5*s.*; packing (parallel), 9*l.*; packing (tapered), 12*l.*; steel billets (soft) 9*l.*; steel billets (medium), 10*l.*; steel billets (hard), 10*l.* 5*s.*; steel boiler plates, 13*l.*; steel ship, bridge, and tank plates, 10*l.* 5*s.*; steel angles, 10*l.*; steel joists, 10*l.*; heavy sections of steel rails, 9*l.*; fish plates, 13*l.*; black sheets, 13*l.* 10*s.*; and galvanised corrugated sheets, 18*l.* 5*s.*

NOTES FROM THE SOUTH-WEST.

CARDIFF, Wednesday.

The Coal Trade.—Increasing production costs, poor trade and declining outputs are playing serious havoc with the Welsh coal trade. As a result of these conditions, colliery owners in a number of cases have been compelled to close down pits, with the resultant discontinuance of work to some hundreds of men. The owners state that they simply cannot go on working at a loss, though it is hoped that the men thrown out of work will soon be absorbed at collieries which are able to pay their way under the present conditions. The 700 men and boys employed by Graham's Navigation Colliery, Sisbewy, have been given notice to terminate contracts, while the Ynysfero Collieries at Treherbert, employing some 1,400 persons, are closing, in addition to the Abergorby Pit of the United National Colliery Company, which employs some 1,800 men. Meantime the demand for coal is still in excess of the supply despite the lower outputs resulting from the closing of pits. In isolated cases salesmen are able to hold for slightly higher figures, but generally buyers are able to secure their needs on favourable terms. The unofficial stoppage of railway shopmen, which lasted 10 days, has ended, and the men returned to work without any concessions. Best Admiralty large coal rules round 28*s.*, with Monmouthshires round 26*s.* 9*d.* and smalls from 17*s.* to 18*s.* 6*d.* Best anthracite large commands 51*s.* 3*d.* and nuts 62*s.* 6*d.* Exports of coal as cargo from South Wales last week amounted to 414,410 tons compared with 469,010 tons in the preceding six days. Shipments to France totalled 171,190 tons compared with 195,060 tons, to Italy 44,630 tons against 16,610 tons, South America 50,370 tons against 100,150 tons, Spain 54,130 tons against 43,130 tons, British coaling depots 31,370 tons against 30,340 tons, and unclassified ports 20,640 tons against 22,570 tons. Exports of coal from South Wales in May totalled 2,280,350 tons compared with 2,250,140 tons in April when there were only 23 working days against 27 in May. Compared with the corresponding month of 1923 shipments showed a reduction at all the ports, the Cardiff total receding from 1,646,410 tons to 1,380,830 tons, Newport from 462,140 tons to 412,100 tons, Swansea from 308,600 tons to 254,390 tons, Port Talbot from 232,180 tons to 197,170 tons, and Llanelly from 65,900 tons to 35,860 tons. France as usual took the bulk of the exports with 924,160 tons, being followed by South America with 333,530 tons, and Italy with 263,150 tons.

Iron and Steel.—Exports of iron and steel goods from the South Wales ports last week amounted to only 5,900 tons compared with 19,390 tons a week earlier. Shipments of tinplates and terneplates totalled 3,028 tons against 8,142 tons, blackplates and sheets to 375 tons against 7,612½ tons; galvanised sheets to 2,014 tons against 2,283 tons; and other iron and steel goods to 485 tons against 1,359 tons.

BRITISH WATERWORKS ASSOCIATION.—The thirteenth annual general meeting of this association will be held in the Council Chamber, Town Hall, Sheffield, on Wednesday afternoon, July 2, and Thursday morning, July 3, when papers will be read and discussed, and visits paid to water reservoirs and pumping works.

NOTES FROM THE NORTH.

GLASGOW, Wednesday.

Scottish Steel Trade.—Little or no change falls to be recorded in the steel trade of Scotland, and little improvement can now be hoped for on this side of the annual trades holidays next month. Forward bookings of any account are almost negligible, and even orders for current requirements do not amount to anything appreciable in the way of tonnage. Producers keep hoping for better times but each day brings its own disappointments, and the daily output is far from satisfactory. The demand for ship-plates has fallen short of expectations, although one or two works have a fair number of orders which, however, do not tax the rolling mills very heavily. Structural sections are not as active as they were, but a fairly good output is general. In the black sheet trade the day-to-day demand is keeping up wonderfully well. The home consumers are not buying to any extent at present and the bulk of the business passing is on foreign account. Heavy gauges are not in much request and most of the specifications at the moment are for the lighter gauges. Little distance ahead can be seen by any of the makers. Prices all round show practically no change and are as under:—Boiler plates, 13*l.* 10*s.* per ton; ship plates, ¼ in. and up, 10*l.* 5*s.* per ton; sections, 10*l.* per ton; and sheets, $\frac{7}{16}$ in. to ¼ in., 12*l.* 10*s.* per ton, all delivered Glasgow stations.

Malleable Iron Trade.—The same old difficulty—shortage of specifications—is the all too general cry from the malleable-iron works in the West of Scotland. The demand is so poor that few mills are turning out a fair tonnage. Prices are being maintained at 12*l.* 10*s.* per ton for "Crown" bars delivered Glasgow stations.

Scottish Pig-iron Trade.—The tone in the Scottish pig-iron market is quietly steady, but buyers are not placing orders for any heavy tonnage in the meantime and are only specifying for their near requirements. Foreign business is coming along with some degree of regularity, but the tonnage is not so large as we are used to getting, and shows caution on the part of buyers. Prices are the turn easier and are as follows:—Hematite, 5*l.* 1*s.* 3*d.* per ton, at the steel works; foundry iron, No. 1, 5*l.* 3*s.* 9*d.* per ton, and No. 3, 4*l.* 18*s.* 9*d.* per ton, both on trucks and at makers' yards.

Scottish Pig-iron Shipments.—The shipments of Scottish pig-iron from Glasgow Harbour for the week ending last Saturday, June 14, were again small, and only amounted to 477 tons. Of that total 428 tons went overseas and 49 tons coastwise. For the corresponding week of last year the figures were 710 tons foreign and 81 tons coastwise, making a total shipment of 791 tons.

Clyde Shipbuilding.—An interesting function took place yesterday (Tuesday) from the yard at Govan of the Fairfield Shipbuilding and Engineering Co., Limited, when the ss. Aorangi was launched. This vessel is to the order of the Union Steamship Company of New Zealand, and is 600 ft. in length, 72 ft. in beam, 46 ft. 6 in. in depth to the lowest weather deck, and of about 23,000 tons displacement. She is the largest, most powerful, and fastest ocean-going vessel yet built to be motor-propelled. The propelling machinery consists of four sets of Fairfield-Sulzer six-cylinder engines aggregating about 13,000 i.h.p., driving quadruple screws and designed to give the vessel a service speed of about 18 knots.

PETROLEUM ENGINEERING: CORRECTION.—In our brief comments on the discussion following Mr. C. Dalley's paper on "Petroleum Engineering," read before Section B, Petroleum, of the Empire Mining and Metallurgical Congress, we stated on page 741 of our issue of June 6, that the paper was discussed by Mr. Carter, Mr. G. W. E. Gibson, Mr. Beeby Thompson and Mr. A. W. Nash. We should have said "and other speakers," and we regret particularly that the name was omitted of Mr. H. Barringer, President of the Institution of Petroleum Technologists, who made a very valuable contribution to the discussion. The words "steam-turbine drill" in the same paragraph should have been "steam-turbine driven high-lift centrifugal pump."

BRITISH STANDARD SECTIONS OF FLAT-BOTTOM RAILWAY RAILS.—The British Engineering Standards Association has recently revised the British Standard Sections of flat-bottom railway rails from 25 to 100 lb. per yard, and particulars of these have been published as Report No. 11A-1924. The issue of the new sections entails some alterations in the British Standard Specification, and a revised edition of this is in course of preparation in which it is intended to include four additional sections of 105, 110, 115 and 120 lb. per yard. The new sections are differentiated from the original British Standard Sections which they supersede by a suffix letter R, *e.g.*, the new British Standard 80 lb. rail is B.S. Section No. 80 R. The primary object of the revision of the sections was to dispense with the double angle in the flange which had been the cause of considerable trouble and expense in manufacture owing to the necessity for the constant re-dressing of the rolls, but other alterations have also been made in the new designs which it is considered should result in the sections being used on many railways which have not hitherto adopted the British Standards. A revised edition of the Standard Specification for Fishplates for Railway Rails will shortly be issued covering new fishplates for use with the modified rails. Copies of the rail specification (No. 11A-1924) may be obtained from the B.E.S.A. Publication Dept., 28, Victoria-street, Westminster, S.W.1, or from Messrs. Crosby Lockwood and Son, 7, Stationers' Hall Court, E.C.4., price 1*s.* 2*d.* post free.

NOTICES OF MEETINGS.

THE RADIO SOCIETY OF GREAT BRITAIN.—To-night, at 6.30 p.m., at the Institution of Electrical Engineers, Victoria Embankment, W.C. 2. Informal Meeting. Mr. J. Ashton Cooper will open a discussion upon "Tuning Coils." Wednesday, June 25, at 6 p.m. Ordinary General Meeting. Lecture: "A *Résumé* of Modern Methods for the Measurement of Radio Signal Strength," by Mr. J. Hollingworth.

THE NORTH OF ENGLAND INSTITUTE OF MINING AND MECHANICAL ENGINEERS.—Saturday, June 21, at 2 p.m., in the Lecture Theatre of the Institute, Newcastle-on-Tyne. Further discussion on "Safety Lamps giving Warning of Gas," by Dr. W. M. Thornton, O.B.E.; "The Scientific Treatment of Boiler Water, introducing the Colloidal Aspect," by Mr. H. W. Bannister. Papers to be read: "The Heat due to Strata Movement and its Effect on Certain Coal-Seams," by Professor Henry Briggs, Ph.D., D.Sc., Mr. A. L. S. Owen and Mr. John Wilson; "The Washing of Fine Coal by the Froth-Flotation and Concentrating-Table Processes at Oughterside Colliery, Cumberland," by Mr. J. G. Scoular, B.A., and Mr. Basil Dunglinson.

THE INSTITUTION OF GAS ENGINEERS.—Tuesday, June 24, to Thursday, June 26, Annual General Meeting, at the Institution of Electrical Engineers, Victoria Embankment, W.C. 2. Tuesday, June 24, at 10 a.m., Presidential Address, by Samuel Tagg, M.Inst.C.E. Report of Advisory Committee on Education, presented by Mr. F. W. Goodenough. "Eleventh Report of the Gas Investigation Committee. Aeration in Atmospheric Burners." At 3.15 p.m. "Twelfth Report of the Gas Investigation Committee, Waste-heat Boilers attached to Continuous Vertical Retorts." "Thirteenth Report of the Gas Investigation Committee. Standard Methods of Testing Gas Cookers." At 8 p.m., Reception and Dance at the Connaught Rooms, Great Queen-street, W.C. 2. Wednesday, June 25, at 10.30 a.m., "The Regenerative Coal Gasification System at Aylesbury," by Mr. A. G. Lane. At 3.15 p.m. Report of Institution Gas Research Fellowship: "The Gasification of Coke in Steam with Special Reference to Rates of Gasification and Composition of Gas Produced," by Mr. Stuart Pexton, Ph.D. and Prof. John W. Cobb, C.B.E., B.Sc., F.I.C. Paper on "Silica Gas Retorts," by Mr. W. Emery. "Report of Refractory Materials Joint Research Committee," introduced by Mr. J. P. Leather. Thursday, June 26, at 10 a.m. "The Construction of New Coal Gas Works at Garston," by Mr. R. E. Gibson. Thursday afternoon, Visit to Paris.

THE INSTITUTION OF NAVAL ARCHITECTS.—Wednesday, June 25, to Wednesday, July 2. Summer Meeting. Jointly with the Institution of Engineers and Shipbuilders in Scotland and the North-East Coast Institution of Engineers and Shipbuilders. Wednesday, June 25, at 10 a.m. in the Great Hall of the Institution of Civil Engineers, Great George-street, S.W.1. "Ship Design," by Sir John H. Biles, K.C.I.E., LL.D., D.Sc. "Advanced Naval Bases," by S. F. Staples and Capt. D. J. Munro, C.M.G., R.N. (Ret.). "Steering in Shallow Waters," by G. S. Baker, O.B.E. "Passenger Ship Design from an Independent Point of View," by John Anderson and Robert Steele, B.Sc. At 3.30 p.m., reception at Syon House, Brentford, by the President and Her Grace the Duchess of Northumberland. At 7.30, Banquet at Connaught Rooms, Great Queen-street, W.C.2. Thursday, June 26, at 10.10 a.m., Visit to the British Empire Exhibition, Wembley. At 10 p.m., Evening Reception, given by H.M. Government at Lancaster House, St. James-street, S.W.1. Friday, June 27, at 10 a.m., in the Lecture Hall, Institution of Civil Engineers, Gt. George-street, S.W. 1, "A Retrospect of Marine Engineering and Possible Lines of Development," by Sir Archibald Ross, K.B.E., "A New Type of Double-Acting Diesel Engine for Marine Purposes," by C. J. Lugt and Harry Hunter, B.Sc. "Displacement-Draught Formulæ," by W. H. Riddlesworth, M.Sc., M.Eng. At 2.25 p.m., River Trip on the Lower Thames. At 9 p.m., Concert at the Hotel Cecil. Saturday, June 28, at 9.30 a.m., Visit to the William Froude National Tank. At 2.12 p.m., Visit to Windsor Castle. Sunday, June 29, at 11.30 a.m., Leave Euston for Glasgow. Monday, June 30, at 9 a.m., Special Trip on the Clyde. At 8.15 p.m., Banquet at the Grosvenor Restaurant, Glasgow. Tuesday, July 1, at 10.30 p.m., Alternative Visits to Works. At 4 p.m., Leave Glasgow for Newcastle. Wednesday, July 2, at 10 a.m., Trip on the Tyne. Alternative Visits to Works. At 7.30 p.m., Banquet in the Grand Assembly Rooms, Barras Bridge, Newcastle-on-Tyne.

EXCURSION TO BEDLINGTON COLLIERY.—An excursion meeting of the Associates and Students' Section of the North of England Institute of Mining and Mechanical Engineers will be held at Bedlington Colliery, on Saturday, June 28.

POLISH EXPORTERS AND IMPORTERS' UNION.—By initiative of the managers of the Poznan Fair, and in close contact with the Chamber of Trade and Industry of Poznan, other Polish bodies, and a number of leading Polish firms, merchants and bankers, there has been established an organisation under the style of the Exporters' and Importers' Union. This organisation is not a trading concern. Its work is disinterested, and its object is to promote and develop trade between Poland and foreign countries by supplying information to Polish and foreign firms and individuals, on the conditions and possibilities of the industries, and export and import trades of Poland. The address of the Union is Skladowa 4, Poznan.

CONTROL GEAR FOR WINDING ENGINE; BRITISH EMPIRE EXHIBITION.

CONSTRUCTED BY THE BRITISH THOMSON-HOUSTON COMPANY, LIMITED, ENGINEERS, RUGBY.

(*For Description, see Page* 793.)

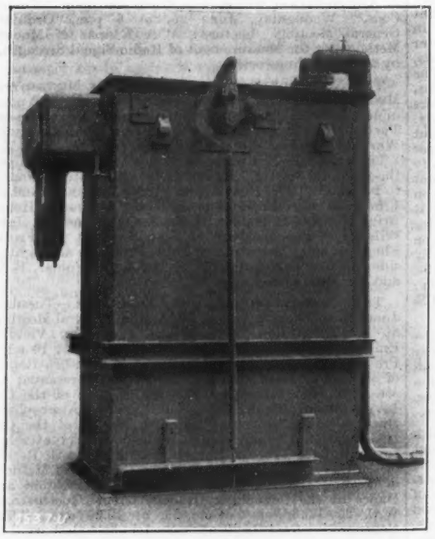


FIG. 63.

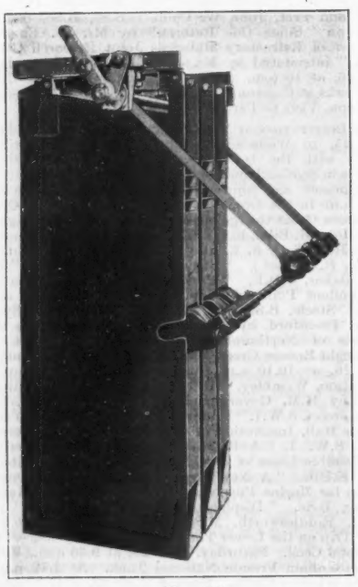


FIG. 64.

FIGS. 63 AND 64. LIQUID CONTROLLER.

THE INSTITUTE OF COST OF WORKS ACCOUNTANTS.—A preliminary announcement issued by this Institute is to the effect that the fifth annual dinner will be held on Thursday, July 24, at 7 for 7.30 p.m., when Viscount Leverhulme will take the chair. The costing conference will take place on the following Friday, at 11 a.m. and 2.45 p.m. On Saturday, July 26, a visit will be paid at the British Empire Exhibition.

THE ROYAL AIR FORCE AERIAL PAGEANT.—A number of new types of military and naval aircraft, which have been developed for Home Defence and other purposes, will be flown in public for the first time at the Fifth R.A.F. Aerial Pageant to be held at the Hendon Aerodrome on Saturday, the 28th inst. High-speed, single-seater fighters will be represented by the Grebe II and the "Woodcock," constructed by the Gloucester Aircraft Company, and the Hawker Engineering Company, respectively, while the two-seater land fighters on view will include the Vickers' "Venture" and the Bristol "Bullfinch." A number of bombers and machines for transporting sick or wounded men are also to be shown, as well as some of the small light aeroplanes developed for the light-aeroplane competition held at Lympne last year. The programme, as usual, includes numerous interesting and striking demonstrations of aerial evolutions calculated to acquaint the public with some of the possibilities of aircraft in warfare.

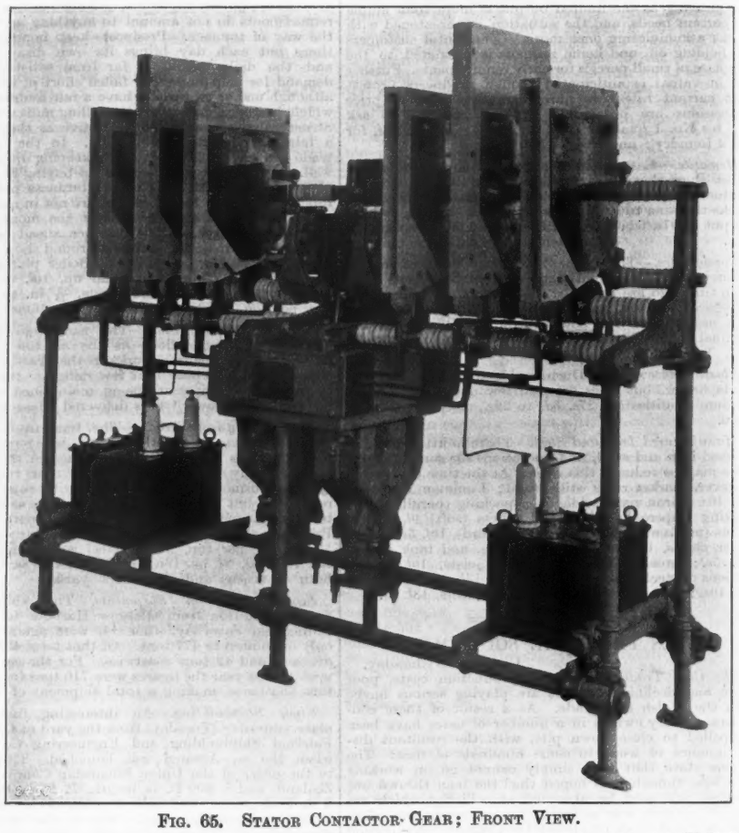


FIG. 65. STATOR CONTACTOR GEAR; FRONT VIEW.

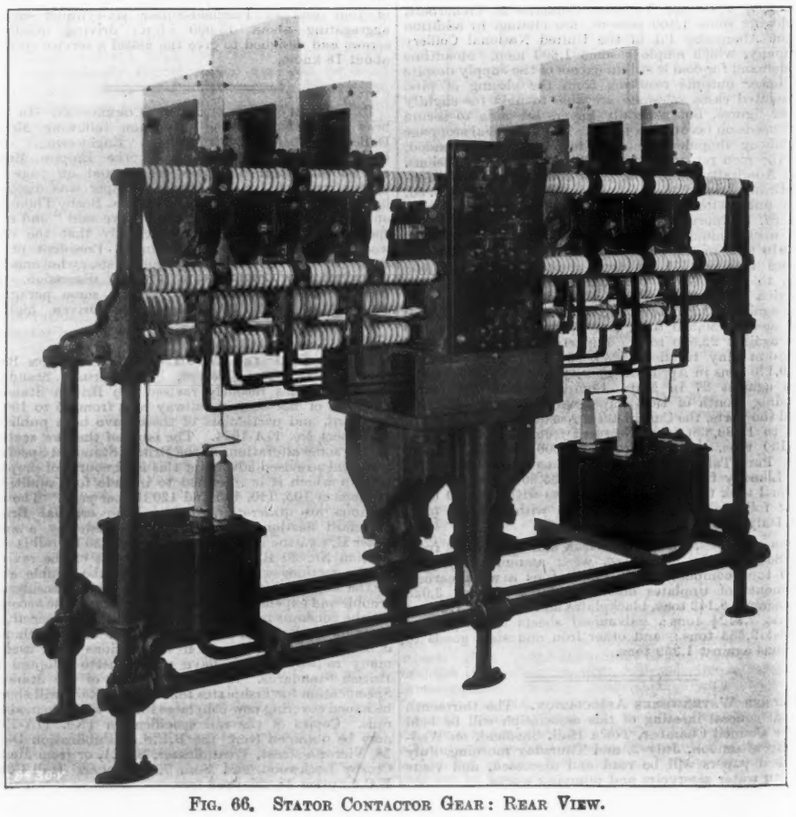


FIG. 66. STATOR CONTACTOR GEAR: REAR VIEW.

ENGINEERING.

Offices for Publication and Advertisements, 35 and 36, Bedford Street, Strand, London, W.C.2.

We desire to call the attention of our readers to the fact that the above is our SOLE ADDRESS, and that no connection exists between this Journal and any other publications bearing somewhat similar titles.

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Advertisements intended for insertion in the current week's issue must be delivered not later than First Post on Thursday. In consequence of the necessity of going to press early with a portion of the edition, alterations for standing advertisements should be received 10 days previous to the day of publication.

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With Three Plates.—60,000-*TON FLOATING DOCK AT SOUTHAMPTON. One Plate.*—*THE GREAT LAKE HYDRO-ELECTRIC SCHEME, TASMANIA.*

ENGINEERING.

FRIDAY, JUNE 20, 1924.

THE CENTENARY OF LORD KELVIN.

THE plantation of Ulster was effected in the reign of James I. To the original settlers were added from time to time others, who in the main consisted of those who resented the then practically universal demand made by priest, presbyter and king that men should think to order. These immigrants whether unitarians, quakers, presbyterians, independents or churchmen, found in Ulster a home where thought was nearly as free as in Holland. To the soil thus attuned to mental development migrated in 1641 three Scottish brothers Thomson, of whom one named John settled near Ballynahinch, where his successors occupied a farm for some 250 years. On this farm was born James Thomson, the father of Lord Kelvin, and himself a man of very exceptional ability and strength of character. By working part of each year at home, James Thomson managed to earn sufficient to maintain himself at Glasgow University during the winter months, and from this University he graduated in 1812 and settled in Belfast, where Lord Kelvin was born on June 26, 1824. From the foregoing, it is very evident that Lord Kelvin conformed with the maxim that "a man cannot be too careful in the choice of his ancestry." A correspondingly favourable environment was secured when eight years later the whole family migrated to Glasgow, where his father had been appointed to the mathematical chair.

It is not our intention to follow in detail the career of Lord Kelvin, but to consider, rather his contributions to engineering progress. Perhaps the most fundamentally important of these had to do with thermodynamics. To-day it is difficult to realise that before 1850 the doctrine of the conservation of energy was not included amongst the recognised maxims of science. Some great generalisations meet with instantaneous acceptance, as did Newton's hypothesis of universal gravitation. Others like that of the conservation of energy, which to-day appears almost intuitive had to fight for recognition through long decades.

As far back as 1798 Benjamin Thompson (Count Rumford) had described experiments which all but conclusively showed the error of the then prevailing doctrine that heat was a material fluid, and in 1799 Davy made the proof irrefutable and, like Rumford, returned to Newton's view that heat must be a mode of motion. Error, however, proverbially dies hard, and never more so than when mathematically entrenched.

The mathematician does not need "to know what he is talking about nor if what he says is true." All he is concerned with, is that his results follow logically from his premises. Even the fact that his calculations may be in agreement with subsequent experiment is not sufficient to ensure that the hypotheses from which he started were sound. It merely indicates that they may be so. Nevertheless, it is universally recognised that, in spite of this inherent inconclusiveness, the mathematical test of a physical theory is by far the best available to us. Indeed, the very fact that an hypothesis can be developed mathematically with results which are in accord with our experience and our common sense is sufficient to create a strong disposition to accept the theory in question as definitely established and a corresponding reluctance to abandon or to modify it.

It was thus with the doctrine of the material nature of heat. With this as a basis, Fourier, in his "mathematical poem" had worked out complete in every essential detail the laws governing the transfer of heat by conduction, and using the same hypothesis Sadi Carnot had been able to deduce certain laws of first importance which held when the transfer of heat from a hot body to a cold one was made, not by conduction but through the intermediary of a heat engine. Whilst still at Cambridge, William Thomson had thoroughly mastered Fourier, and during his stay in Paris in 1845 became acquainted with Carnot's fundamental theorem. In view of the immense mass of material co-ordinated by these great discoverers, it is not surprising that a very strong predilection was created in favour of the hypothesis from which both had started. The consequence was that when Joule commenced to read his famous paper at Oxford in 1847 William Thomson felt that the doctrine then brought forward must be fundamentally wrong and intended to get up and say so in the ensuing discussion. As the paper proceeded however, the conviction dawned that whilst the theory as developed by Carnot must be true in essentials, there must also be some other great physical truth embodied on the research described by Joule. Hence in place of scathing criticism, Thomson's contribution to the discussion emphasised the fundamental interest and importance of the experiments described. Nevertheless, he remained still unconvinced for some years.

Had he known less, conversion might have been easier, more particularly as he had long recognised one difficulty in the old theory; he was haunted by the query as to what took the place of the "mechanical effect" of the engine when the heat passed from "source" to "sink" by conduction. According to the theory in both cases as much heat reached the sink as left the source, but in the one case we appeared to be presented with a bonus in the shape of the work done by the engine. It is difficult to realise to-day the slowness with which the idea made its way that the explanation was to be found in the falsity of the hypothesis that heat was a material fluid both indestructible and ingenerable, and that it was merely one of the protean forms of energy.

Shortly after the reading of Joules' Oxford paper, Stokes wrote that he was himself inclined to be a "Joulite," but intense as was Thomson's admiration for, and confidence in, Stoke's judgment, he still remained unconvinced, though he kept in constant correspondence with Joule. Finally, in 1849 conviction came. In the meantime Rankine,

with the aid of a special hypothetical working agent, had succeeded in showing how Carnot and Joule could be reconciled and had given his results in a paper presented to the Edinburgh Royal Society where is to be found the "Thermodynamic function" to which Clausius subsequently gave the name of entropy.

Once clear of his difficulties Thomson proceeded with giant strides and in his paper of 1852 "On a Universal Tendency in Nature to the Dissipation of Energy," he laid down in the most general possible way the principle now commonly expressed by the statement that the entropy of the universe tends to a maximum. In this paper he retained Carnot's function in its most general form, though Joule had suggested to him in 1849 that this function was sensibly equal to the reciprocal of the absolute temperature indicated by the air thermometer. This concept of absolute temperature seems to have originated with Joule, but Thomson had already seen that Carnot's theorem provided a scale of absolute temperature which was quite independent of the physical properties of the substance used in a thermometer and was engaged with Joule in testing how far the two scales agreed. In the meantime he retained Carnot's function in the general form, with the result that the expressions in his paper are much more complicated than necessary. This, no doubt, has been largely responsible for the subsequent neglect of his researches and to the attribution to others of many of his original discoveries. Possibly less than justice has been done to Thomson in the foregoing, by the emphasis laid on the slowness with which he accepted the new ideas. If he did not accept them, however, he at least recognised their importance, and probably his interest had much to do in influencing others to study Joule's claims.

The way was now clear for the establishment of the doctrine of the conservation of energy as a basic principle in physics, but it was not till 1867 that an authoritative text-book was published based on this concept. This was the famous "Natural Philosophy" of Thomson and Tait.

There appear to be two types of physical investigator, viz., those who are content with being able to calculate results, and those who wish to understand the underlying phenomena. The former school, for instance, would be content to show mathematically from the adiabatic law of gas expansion that the discharge from a nozzle became a maximum when the ratio of the inlet to discharge pressure attained a certain definite figure. The other school cannot be so easily satisfied, but want to picture in their mind's eye the actual mechanism involved. In the case under consideration this was ultimately described by Osborne Reynolds, who pointed out that if a change in the external pressure involved an increased discharge there must be some alteration of the conditions inside the nozzle box, so as to provide for the increased flow. The "news" of external changes being "telegraphed" back along the issuing jet, at the speed of sound could not be transmitted to the interior once the velocity of efflux reached this limit, and hence no subsequent change in the external conditions could affect the internal conditions.

Lord Kelvin belonged most emphatically to this second type of investigator. He said that unless he could "make a mechanical model all the way through" he could not understand phenomena. In this he resembled Faraday, but Kelvin was in addition an accomplished mathematician, being both erudite and creative, and excelled moreover in the capacity for translating physical and mechanical problems into mathematical form. This, Helmholtz has pointed out, is a much rarer gift than the capacity for manipulating formulas, and Thomson, he said, was endowed with the ability in question to a most unusual degree.

This gift found a virgin field for its exercise when the question arose of laying a submarine cable to America. Crampton had laid the cable to France in 1850, and this was followed by a number of other short lines. The engineers in charge of these had noted a certain retardation of the signals, and Faraday, with characteristic insight, had pointed out that owing to the high specific inductive capacity of guttapercha, this retardation might be very serious in a cable 2,000 miles long.

Two important questions then arose, viz., how would the retardation vary with the length of a cable, and secondly, what method of working would minimise the inconvenience? Both problems were attacked experimentally by a Dr. Whitehouse, a retired physician and amateur electrician, whilst Thomson solved the first mathematically and the second by reasoned experiment. Whitehouse completely misinterpreted his own observations. It is, of course, generally accepted that although a gift for ingenious experiment is quite common, the ability to interpret novel results is rare. The researches which led to the discovery of radium, for example, were well within the capacity of most physicists, but such insight as that which attributed radioactivity to an atomic disruption is possessed by very few.

By an ingenious application of the methods by which Fourier had discussed the flow of heat, Lord Kelvin showed that, other things being equal, the retardation in a cable would increase as the square of the length, so that a retardation of one-tenth sec. in a cable 200 miles long would become 10 sec. in a cable 2,000 miles in length. This result was disputed by Dr. Whitehouse on the basis of his experimental figures, but, as Thomson pointed out, the failure to find the true value was due to the imperfection of the receiving instruments employed. That there was a retardation was, however, admitted, and to overcome this Whitehouse proposed to use very high voltages, whilst Kelvin set to work to produce his mirror galvanometer. His mathematical investigations had shown him that the electrical impulse transmitted along the cable spread out as it proceeded, and the important point was to get an instrument with such small inertia that it would respond to the attentuated current which arrived in advance of the main flow. He also showed that there would be an advantage in earthing the sending key after each signal. His reasoning was too recondite to be readily grasped by business men, to which the "common-sense" point of view of Dr. Whitehouse made a much more convincing appeal. It sounded so reasonable that high voltages should reduce retardation, and that the receiving instruments should be a "good solid mechanical job." As a consequence, Dr. Whitehouse was appointed chief electrician to the company, but refused to accompany any of the laying expeditions. Kelvin, owing to the influence of Glasgow subscribers to the venture, was himself a director of the cable company, and on Dr. Whitehouse's refusal to go to sea was requested by his colleagues to go instead, and he had thus the opportunity, of which he fully availed himself, of making many important observations, which led subsequently to material improvements in the cable-laying gear.

It was in connection with the manufacture of this cable that Thomson discovered that the conductivity of commercial copper varied from 42 per cent. to 102 per cent. He called the attention of his co-directors to this, but Whitehouse assured them that conductivity had nothing to do with the speed of signalling. By obstructive tactics however, Kelvin compelled his board to specify a good conductivity for the 700 miles of new cable which had to be made to replace what was lost on the first expedition in 1857; and to ensure compliance, a testing laboratory was set up at the factory.

Whitehouse again refused to accompany this second expedition of 1858, and, moreover, would seem to have had some doubts as to the reliability of his own views and apparatus, since, although instructed by the directors to use the complete cable, whilst it was still on shore, in order to train operators; and to test his appliances he did nothing of the kind. In the meantime, Kelvin had devised the mirror galvanometer, and again accompanied the cable laying expedition. This time the task was successfully completed, messages were clearly transmitted by means of Thomson's instruments. The ultimate outcome was to establish Kelvin as *the* authority on long submarine cables, and in conjunction with Fleming Jenkin he was the responsible engineer for most subsequent work of this kind.

In this connection, it is of interest to note the difference in the treatment he received from "directors intent merely on profits" and from a Government department, which we are often assured is actuated by no such sordid motives and is merely concerned solely to do the right.

As is common knowledge, Lord Kelvin effected most fundamental improvements in the construction of the mariner's compass. Some sixty of his instruments were installed on various naval vessels. Of the official reports called for, one only made some slight objection, eight said they had insufficient experience, and the remainder were enthusiastically favourable. The Admiralty, however, suppressed all but the one unfavourable report. This abuse was ultimately exposed by Lord Fisher. In contrast with this, when Kelvin desired an extension of his patents for the mirror galvanometer, the cable companies treated him very fairly, although considerable pecuniary interests were at stake.

Perhaps the work Kelvin did in establishing the present system of electrical units was of as much engineering interest and importance as any of his other work. He played a leading part in founding the British Association Committee, which made the first absolute measurement of the ohm. It is difficult to realise that so recently as the Paris Congress of 1883 there were distinguished continental electricians who favoured Siemen's proposal to take as the unit of resistance a column of mercury 1 m. long and 1 mm. in cross section. Such a standard would, of course, have had no simple relationship with the fundamental C.G.S. system. Kelvin's influence was thrown strongly into the scale against this proposal to adopt a purely arbitrary unit of resistance, and with the invaluable support of Helmholtz he succeeded in carrying the day.

Throughout his life Kelvin was a strenuous critic of the British system of weights and measures, and an equally ardent advocate of the general adoption of the metric system. In this connection it is, however, very curious to note how old habits persist. The kilogramme as now defined is the mass of a certain block of platinum, but in practice continental engineers, in general, persist in defining it as the weight of this mass, thus needlessly introducing in their formulas the gravitational constant and recreating for themselves the same ambiguity in the use of the word kilogramme, that we have in the case of the term lb., which is used indifferently as a measure of mass and as a measure of force.

It is not within our province to discuss Kelvin's mathematical contributions, but it may be noted that the appendix to the "Natural Philosophy" of Thomson and Tait, treated spherical harmonics from an entirely novel point of view. As a lecturer Kelvin is said to have often talked over the heads of his students, but that he had remarkable powers of exposition is strikingly evidenced by the appendix to his article on Heat, in the ninth edition of the Encyclopedia Britannica, where the salient points of Fourier's theory of heat flow are condensed into a little more than two pages of text and without any sacrifice of intelligibility. His article on "Elasticity" in the same volume is moreover a particularly noticeable piece of work, and is still valuable, not only for its exposition of principles but also for many experimental results, the full bearing of which is still very imperfectly understood. He discovered that wires could be "trained" to carry weights which if imposed on them at the outset would have involved immediate fracture. He also investigated what would now be called elastic hysteresis and discovered that twisted wires seemed to have something analogous to "memory."

His investigations relating to the age of the earth and of the sun were both ingenious and disconcerting, as they tended to reduce almost to insignificance the aeons of ordered life which geologists were compelled to claim from their own researches. The discovery of radioactivity has of course entirely undermined the basis on which Thomson's calculations rested.

As its long life neared its close Kelvin, who had received nearly every scientific honour open to him in the world, summed up his career as one of failure. In fact he had started it with the idea of reducing all physical phenomena to mechanism, and at the outset, progress along this line was so rapid and triumphant, that the ultimate goal seemed well in sight. As knowledge increased, however, and

measurements became more precise, many facts became inexplicable along the lines of the classical mechanics. In this way therefore Kelvin failed of his aim, but nevertheless his permanent contributions to human thought place him amongst the very foremost figures of the Victorian age, and well merit the almost world-wide centenary tributes of the forthcoming fortnight.

FIRST LARGE DIESEL-ENGINE-DRIVEN PASSENGER LINER.

THE launch on Tuesday last by the Fairfield Shipbuilding and Engineering Company, Glasgow, of the quadruple screw motor passenger ship Aorangi is of much more than passing interest, as marking what undoubtedly promises to be the commencement of a new epoch in the history of marine engineering. No firm is richer in traditions than the builders of this vessel and her machinery, and the history of the developments in steam propulsion fostered by John Elder, Dr. A. C. Kirk, and Sir William Pearce in the early days of the history of mechanical propulsion will be remembered. A comparison of the dimensions of this ship with the first Aorangi of 1883 serves to indicate the progress made. The new ship is 200 ft. longer, 26 ft. broader and 13 ft. deeper, carries 700 more passengers, and is of 13,000 more tons gross.

This large motor vessel will be the latest addition to the fleet of 75 vessels, of 280,000 tons gross, of the Union Steamship Company of New Zealand, who have always been in the forefront in taking full advantage of the latest improvements in propulsive means. They adopted very early the combination of reciprocating engines exhausting into turbines; they were the first firm to have marine turbine machinery in service at the other side of the world, and the Aorangi will be the first large and high-speed Diesel-driven passenger liner in service.

In all respects the arrangement and the finish of the passenger accommodation is of the very latest and most modern type, so that this vessel will rank with the finest afloat. The length is 600 ft. by 72 ft. broad and 46 ft. 6 in. in depth to the lowest weather deck. There will be accommodation for 440 first-class, 300 second-class passengers, along with a complement of 330 officers and crew. A speed of 18 knots is anticipated. The adoption of internal combustion machinery has facilitated the provision of large and spacious reception rooms, cafés, &c., in keeping with the latest requirements of first-class passenger service.

Chief interest, as marking a distinct and bold departure from previous practice, centres in the propelling machinery. We gave the leading particulars when describing the running of the first of these sets on the test trial (page 376 *ante*). Each of the four main engines has six working cylinders of 27½ in. diameter by 39 in. stroke, and develops 3,250 brake horse-power at 135 revolutions per minute. The third engine has completed shop trials and was inspected running in the engine shops by the visitors after the launch. This engine is composed of six units similar in size and power to Sulzer Diesel engines of four working cylinders already at sea, and to this considerable extent represents a highly developed design. The main engines of the Aorangi are, however, of six cylinders, and when the ship is in service she will be the highest powered marine Diesel engine afloat. The design has been due to collaboration between the builders and their licensors, Messrs. Sulzer, of Winterthur, Switzerland.

It has been cause for remark and some criticism that four engines, shafts and propellers have been adopted. There would not appear to be any serious ground for criticism in this respect. There are to-day Atlantic liners with steam turbines and four shafts revolving normally at much less suitable speeds of revolution than the Aorangi, and these vessels have given excellent service and continue to perform admirably. In complimenting alike the Fairfield Company and the owners of the vessel, the Union Steamship Company, for the courage shown in the construction of this vessel, it must be remembered that the service of the ship will be between Australasia and Canada on a far distant route.

The consumption of fuel oil as compared with that of a steamer with oil-fired boilers will be much less than a half; and the economy so effected should go far to popularise this class of vessel amongst progressive shipowners, assisting the revival in the shipbuilding industry so much needed to maintain our premier place in the world's sea trade.

The steady growth of the marine oil engine industry on the Clyde into its present position is in keeping with all the traditions of the river, and the performance of this ship at sea will be watched with the very closest attention. It is hoped that the vessel will be completed this year.

THE ROYAL SOCIETY SOIRÉE.

MOST of the novel exhibits of interest to our readers at the second Royal Society Soirée of this season, held last Wednesday, have already been noticed in our issues of May 16 and 23, when we commented upon the first soirée. Last Wednesday there was only one discourse, a demonstration of recent developments in high-speed kinematography given by Professor Lucien Bull, of the Mareg Institute, Paris. The high-tension disc battery, exhibited by Major C. E. S. Phillips, is a modification of the historical Zamboni pile which should not have fallen into disuse. The pile consists simply of discs of paper, covered on the one side with foil of Dutch metal and on the other with aluminium foil; these discs are piled up in a cardboard cylinder, wax-lined inside; metal discs at the top and bottom serve as terminal electrodes. The batteries remain unchanged for years, varying very slightly only with the weather in their potential difference, which may range up to 1,000 volts. The batteries are convenient for maintaining an electrometer needle at a constant potential, as owing to their high internal resistance they may be short-cuited for hours.

This was demonstrated by means of a small oscillating lever which will keep oscillating between two terminals, joined to a small battery of this type, for many years without requiring any attention, provided friction be reduced to a minimum. Major Phillips attains this condition by means of his magnetic pivot, a simple device by which a delicate pivot may quickly be set up. The round-pivoted end of a steel needle rests axially between a hard steel rod, against which it bears, and the pointed pole of a magnet which can be adjusted in the axial line of the three parts. The one end of the needle being free, the needle is nearly lifted from its support by the magnet, and the frictional resistance to rotation of the needle is very small. This magnetic suspension was also shown arranged vertically. A magnet was suspended vertically and adjustably over a mercury cup, and a sewing needle was resting on the mercury, so lightly as not appreciably to dimple the surface, there being a gap of quite a quarter of an inch between the top of the needle and the pole. This "magnetic pivot" might be utilised in various ways. The acoustic spectroscope, exhibited by Dr. E. E. Fournier d'Albe, is an apparatus designed to analyse sound and follow a series of sounds visually. There is a series of Helmholtz resonators, tuned to different pitches, consisting of small wooden boxes, each having a mica reed at the top; each reed bears a small mirror. The light from a lamp is reflected by all the mirrors and produces a series of lines on a ground glass screen. When a mirror vibrates in resonance with one of the sounds, the respective image is disturbed.

We should like also to mention, as an exhibit of historical interest, apparatus illustrating "bygone methods of ignition," shown by Dr. Michael Grabham. There were steel and flint igniters, Döbereiner's hydrogen and spongy platinum apparatus, and a curious combination apparatus used by Charles Wheatstone. He made the jet of hydrogen from a generator pass through a spark gap and on to a candle; the turning of the hydrogen tap also excited an electrophorus which gave the igniting spark.

THE NAVY AT THE BRITISH EMPIRE EXHIBITION—II.

NAVAL exhibits in the Palace of Engineering are of so comprehensive and varied a character that few can fail to find many which are of more than ordinary interest. There is here displayed more than enough to satisfy the curiosity of the ordinary visitor, whilst the engineer, whatever branch of the profession he is more particularly concerned with, will find many new and ingenious machines and applications.

Messrs. Vickers occupy we think the largest space in the Palace and have provided an excellent and varied exhibit. Those who are familiar with the name and fame of the firm from their many achievements in the production of warships and their armaments, and of weapons of war generally, will perhaps be surprised with their many productions in more peaceful directions. They will notice almost side by side with the guns, howitzers, mines and other deadly weapons, sets of golf clubs and other appliances of a peaceful nature.

A large naval gun overshadows the rest of the exhibit, for it is full size, and pointing at a considerable elevation stands out as a landmark visible from almost every point of the Palace. The calibre of the gun is 16 inches, it has a length of over 60 ft. and the actual gun which it represents weighs nearly 110 tons. The breech end and the breech mechanism are taken from an actual gun. Interesting as a triumph of mechanical skill, it is made more so by the fact that in accordance with the provisions of the Washington Treaty, it is the largest calibre gun which can be mounted in capital ships whilst the Treaty is in force—until November, 1931. The weight of the projectile which it fires is 2,240 lbs., and the height over 6 ft.; the charge weighs 520 lbs. and can send the projectile a distance of 22 miles with a muzzle velocity of 2,450 ft.—nearly half a mile per second. The shot would force its way through a plate of wrought iron nearly 5 ft. thick if the latter were placed at no great distance from the muzzle. The breech block, weighs nearly 3 tons. The majority of the capital ships of the nations are armed with 15-inch guns weighing about 90 tons and firing a projectile of about 1,900 lbs weight. A few guns of larger calibre than 16 in. were fitted in warships between 1914 and 1918. These were 18 in. calibre firing projectiles whose weight was one ton and a-half, and were mounted in a few monitors and also in the large light cruiser "Furious." A comparison of the 16-in. gun with the bombard in the Government pavilion, which fired a 15-in. stone sphere weighing 160 lb. with a charge of powder of about the same weight a distance of perhaps 300 ft., indicates the great advancement made in gunnery during five centuries.

The mechanism of the breech block of the 16-in. gun is well worthy of study being of a new design, and operated by hydraulic power which opens or closes it in 1½ seconds. Using an auxiliary hand-pump the operation only requires 8 seconds even when the gun is elevated 15 deg. Two hydraulic cylinders are fitted, one to swing the breech block and its carrier, the other to rotate the block, an interlock preventing rotation before the block is in the correct position. The energy of the moving block and carrier when closing is utilised to rotate the breech block. For this purpose two cams fitted to the gun breech engage two rollers on the flange of the breech block screw, and turn the latter as the carrier reaches home, thus absorbing the energy of the moving mass and reducing the shock. The energy of the mass when opening is dissipated by a throttle valve on the opening piston and by a buffer moving into a dash pot.

Other sizes and descriptions of guns find a place in the exhibit. Amongst these is a 7·5-in. naval howitzer of simple design and a 0·5-in. automatic gun fitted with a funnel-shaped extension on the muzzle to prevent the flame being seen when firing. The gun is watercooled, weighs 66 lb., and can fire 400–600 rounds a minute with a muzzle velocity of 2,500 ft. a second.

In close proximity to the guns is a Vicker's submarine mine (Fig. 3), used in very great numbers, especially during the latter part of the Great War. There seems little doubt the enemy was prepared at the outset for an extensive use of this deadly weapon,

for the first operation of the naval war was the detection and sinking of the Königin Louise, which was laying mines off the English coast. One of these mines caused the sinking of the light cruiser Amphion shortly afterwards. The naval authorities of the Allied powers do not appear to have anticipated the intensive use of this weapon, and consequently large numbers had to be ordered after the outbreak of hostilities, and of these Messrs. Vickers supplied the majority. The details of the mines were improved as experience in manufacture and actual use was obtained, and the mine which is exhibited is one in which these modifications have been embodied. The mine is of the "buoyant combination" type, and consists of two main portions, the mine and the sinker. The former is a spherical steel casing 41 in. in diameter, which will contain about four hundredweight of explosive. The sinker is a heavy weight of cylindrical shape rigidly secured to the mine when ready for use. When launched overboard the whole sinks, but returns to the surface after a few seconds. After a short interval the sinker is freed from the mine and sinks to the bottom, remaining attached to the mine by a steel wire rope—the mooring rope—which is wound around a reel in the sinker and is paid out as the sinker falls to the bottom. By an ingenious device the mine is kept at a depth of from 6 to 20 ft. below the surface of the sea by the steel wire rope, these limits of depth being sufficient to prevent the presence of the mine being detected and not too great for the draught of ordinary ships.

The mine is fitted with horns on the upper portion. These are of lead casing, each enclosing a glass tube which contains a solution of potassic bichromate and sulphuric acid. The slightest contact with one of these horns causes the glass tube in it to break, the chemical solution is discharged into an electric cell, hitherto inert but which now becomes active. A current is generated which fires the detonator, and the charge is exploded.

A control gear is fitted, which when in action prevents explosion of the charge. This gear depends for its action primarily upon a soluble plug which is arranged not to dissolve in less than 30 minutes after the mine is laid. After this the gear is held out of action by the tension of the mooring rope. If the wire parts, the mine breaks adrift and the action of the control gear prevents it exploding.

During the first few months of war the extensive laying of enemy mines and the frequent losses of ships caused thereby, forced the naval authorities seriously to consider the fitting of appliances to ships by which mines were swept clear of a vessel's course. Many forms of bow protection were designed and tried, and generally consisted of booms or structures standing out ahead from the stem and from the sides, between the outer ends of which wires were stretched. A crinoline of wires was thus formed in advance of and around the bow of the ship to which the protective device was fitted. Any mines lying in the course of the ship were swept aside or the mooring wires broken. Nearly all these devices were dropped when the paravane (Fig. 4) had proved it was more successful for the object in view. This useful appliance was the invention of Commander Burney. Messrs. Vickers secured the rights of manufacture of the paravane, which in the latter part of the war was fitted to practically all war and merchant ships of the allied nations. One example is exhibited and it will be seen its main body is of a torpedo or fish shape fitted with planes and fins, which are of such areas and so disposed that when towed by the ship, the paravane stands out laterally from the side of the ship, maintains a course parallel to the latter, and at a depth which can be set by an automatic device in the main body. A towing frame secured to the head is fitted at the top, near the security for towing wire, with a wire cutter, and at the bottom a long curved plane at one end of which is a float and at the other a weight, to keep the paravane in the correct position when towed. A paravane was towed on each side of the bow, the two towing wires being led to a position on the stem well below water. The towing wires thus form a spear head to the ship, and the mooring wires of any mines which were fouled were guided by the towing wires to one of the paravanes whose cutter severed the mooring wire. The mines were thus released far from the ship's side, rose to the surface, were seen, and destroyed.

Another exhibit is a sectioned sample of a depth charge which was introduced during the war, and large numbers made for the special purpose of destroying enemy submarines. It has a cylindrical steel case of sufficient capacity to carry a charge of 300 lb. of T.N.T. On the upper portion of the cylinder is fitted a depth adjuster by which the depth below the surface at which the charge is

FIG. 3. SUBMARINE MINE.

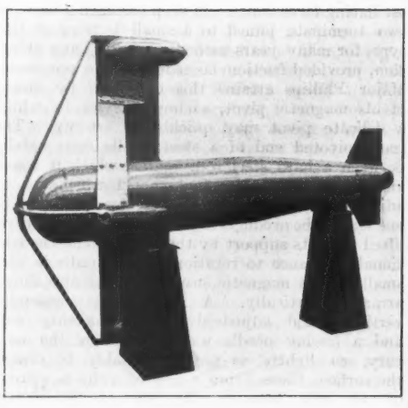


FIG. 4. PARAVANE.

exploded can be regulated. A pistol is fitted to detonate the charge, and is fired by hydrostatic pressure on a diaphragm. A series of small holes in the depth adjuster provides the only means of access for water to the diaphragm, and by varying the size of the holes by the adjuster the interval which elapses between the time the depth charge enters the water and the moment that sufficient pressure is available for the diaphragm to function can be regulated and with it the depth of explosion. The pistol can be set to fire the charge at depths of from 50 to 500 ft. Vessels engaged in anti-submarine work were fitted with depth charge throwers somewhat similar to howitzers. The depth charge was held horizontally in a semi-circular tray fitted at right angles with a wooden spindle which was inserted into the muzzle of the thrower. Depth charge, tray, and spindle were discharged together by the thrower. The explosion of the depth charge was very effective, not only in injuring the hull structure of the submarine, but also in lowering the morale of the crews of the vessels against which it was used.

Some excellent models of warships built by Messrs. Vickers are exhibited, amongst these being the Japanese battle cruiser Kongo, completed in August, 1913. The length of this vessel is 704 ft., beam 92, and displacement 27,500 tons. The shaft horse-power of the turbines as designed was 64,000, but nearly 80,000 was developed on the trials, giving a speed of 27½ knots. The main armament consists of eight 14-in. guns mounted in four turrets, with a secondary armament of 16 6-in. guns, four 12-pdr. anti-aircraft, and some smaller guns. Eight 21-in. submerged torpedo tubes are installed. The fuel carried is mainly coal, but provision is made for 1,000 tons of oil fuel. Three sister ships to the Kongo were built in Japan, the first of these being completed on the outbreak of war and the other two in 1915.

A model of the São Paulo, a Brazilian dreadnought, built by Messrs. Vickers in 1910 is also shown, docked in a model of a floating dock also constructed by the firm. The ship is of 19,000-tons displacement, and the engines developed 26,000 s.h.p. on trial, giving a speed of 21¼ knots. She has the distinction, with her sister the Minas Geraes built by Messrs. Armstrong, of mounting a main armament of 12 guns as compared with 10, the standard Dreadnought armament. The guns are of 12-in. calibre, the secondary armament being 4·7 in. and 18 in number. As with other capital ships of the same date of construction, the fuel carried is principally coal, but stowage is provided for nearly 400 tons of oil.

The floating dock is 550 ft. long 136 ft. outside width, with 100 ft. clear docking width, and is capable of lifting a ship of 22,000-tons weight. It was built in three sections which after launching were bolted together. The necessary machinery, workshops and appliances for carrying out extensive refits to vessels on the dock are installed in the walls. The towage of the dock from Barrow to Rio Janeiro was one of the longest and most successful of such hazardous enterprises.

Three other vessels of a far different type to the São Paulo were built by Messrs. Vickers for Brazil, and were just completed when war broke out in 1914. They were purchased by the British Government, and became H.M.S. Humber, Mersey and Severn, the first of the monitor class which were ready for Naval operation. A model of the vessels is exhibited. Designed by Sir George Thurston, the Naval Designer of the firm, the vessels were 265 ft. in length, 49 ft. beam with a draught of 4½ ft. The displacement was 1,520 tons, the engines of 1,200-h.p., gave a speed of 12 knots. The armament, as carried during the war, was three 6-in. guns and two 4·7-in. howitzers. Intended by the Brazilian Authorities for river service, they were used with good results during the war in the Dardanelles, and on the East African and Belgian coasts.

Excellent models of three famous types of British submarines are also exhibited, these being of the E, K and M classes. The first-named class were the latest type available at the outbreak of war, and bore the brunt of the work in the early period, E4 the first in commission having been built by Messrs. Vickers, and completed early in 1913. Over 20 others of the class were built at Barrow. The K class submarines, the largest built during the war, were fitted with steam turbines for surface propulsion in place of the internal-combustion engine usually employed, and obtained a speed of 24 knots on trial. Six of this class were built by the firm and included K3 the first to be completed. The M class of which three were built during the war, are famous as mounting a 12-in. gun the largest fitted in a submarine vessel. M1 and M2 were built by Messrs. Vickers.

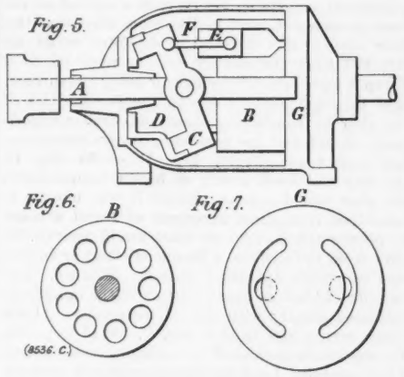
In this particular and very special branch of warship construction, Vickers Limited, have done excellent work during the past 24 years, having built no less than 140 submarines for the British Navy. The first built by them—Holland No. 1—was ordered in December, 1900. The last-completed submarine, K 26, was started by Messrs. Vickers in 1918, but in 1919 was ordered to Chatham for completion, the works at Barrow having built the hull, constructed the boilers and machinery and practically the whole of the fittings in the vessel.

Except for one class of submarine—the J class—the firm have contributed to classes and have prepared the drawings for the first vessel of each class. The J class were built in the Royal Dockyards. The Vickers' internal-combustion engine, with solid fuel injection and developing 100-b.h.p. per cylinder, has been fitted in practically all British submarines, and had either eight or twelve cylinders.

One other branch of warship construction in which the firm are pioneers in this country, and which has occupied a prominent position in recent discussions in Parliament, is not represented in the exhibit. This is the rigid airship, of which some half-a-dozen were built at Barrow. R 80 completed by the firm after the Armistice, is a fine example of this very delicate type of construction and well worthy of representation by its model.

One portion of Messrs. Vickers' space is allocated to the exhibits of the Variable Speed Gear Company, who construct the Williams-Janney speed gear which is being used for a variety of purposes and especially on warships.

Figs. 5 to 7 show diagrammatically the construction of the gear. A is a shaft coupled to the driving shaft of a motor or prime mover. B is a cylinder keyed to A and bored with several holes parallel to the axes of A to form equispaced cylinders for an odd number—5, 7 or 9—of small pistons of which A pipe is led from each slot. If the pipes and cylinders are full of oil, half the pistons will be forcing oil through one slot into the pipe leading from it, and the remaining pistons withdrawing oil through the slot from the other pipe. The mechanism is thus



FIGS. 5 TO 7. WILLIAMS-JANNEY VARIABLE SPEED GEAR.

up to the maximum revolutions of the driven shaft Roller and ball bearings are fitted to all parts, the lubrication is very complete, and it is claimed that the efficiency of transmission of power is very high and is maintained even if the motor end revolves at a small number of revolutions. The torque transmitted is thus inversely proportional to the number of revolutions. The mechanism driven by electric motor or other power is termed the A end, and is always arranged so that its inclined tray can be moved. The other end—the motor end—is termed the B end, and its inclined plate is maintained at a constant angle. In place of two pipe connections, the A and B ends can be placed end to end and bolted together. Pipes are convenient when, as on a ship, the electric motor and A end are fitted between decks, and the B end and the mechanism it drives are on the weather deck. The inclined plate of the A end is then operated by control shafting from the weather deck near the appliance which is being driven. Working pressures of from 600 to 1,500 lb. per square inch are usual, but higher pressures can be obtained. The A end is driven direct by an electric motor and generally revolutions of at least 600 per minute are arranged for. Speed gears suitable for various powers to be transmitted up to 200 h.p. are exhibited, but units for 500 h.p. have been made.

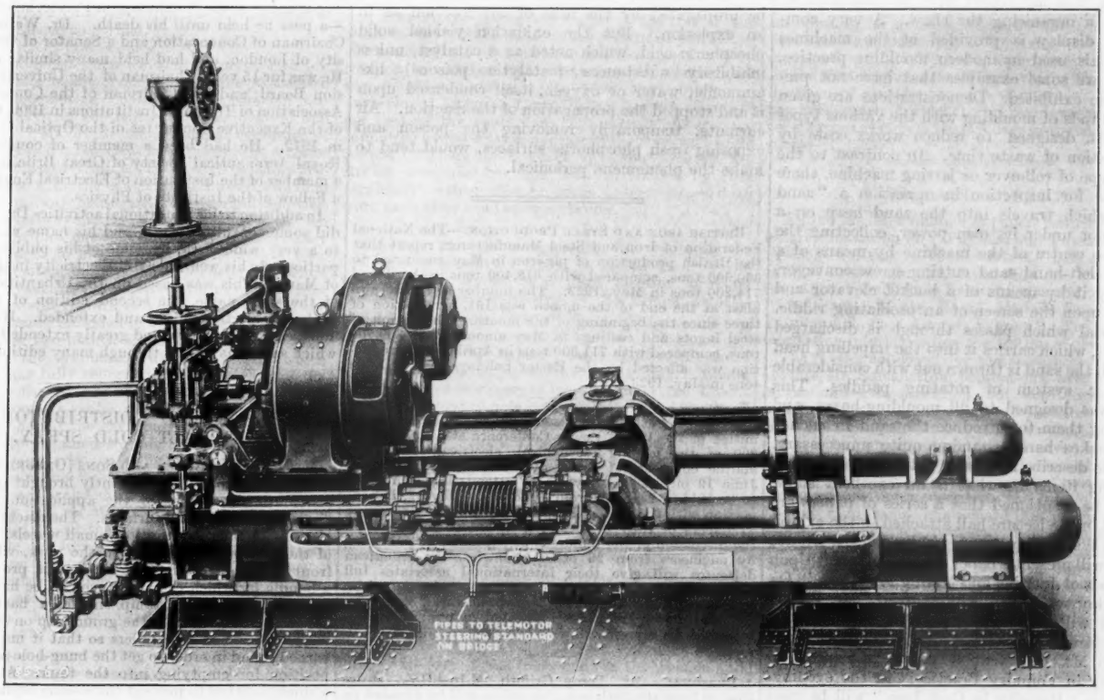


FIG. 8. WILLIAMS-JANNEY ELECTRIC HYDRAULIC SHIP STEERING GEAR.

E is one. F is the piston rod connected by ball and socket joints to E and to an inclined disc C keyed to A. C can also move about a horizontal axis perpendicular to and intersecting the axes of A. D is an inclined circular tray fitted with roller bearings on the flat portion and around the inside of rim. C fits against these bearings in D. D cannot rotate about the shaft axes, but remains in an inclined position, which can be varied up to about 20 deg. on either side of the vertical. When A rotates, any point in C, such as the end of piston rod F, approaches the face of B during half a revolution, and recedes from it during the other. The pistons situated on one side of a vertical diameter of B are thus forced into their corresponding cylinders, and those on other side of the diameter are withdrawn.

At the right of B is a fixed plate G cut with two annular slots, one on each side of a vertical diameter. The radius of the central line of the slots is the same as that of the centres of the cylinders. acting as a pump, whose discharge can be varied by altering the inclination of D and with it that of C. If D is vertical, there is no suction or discharge. If D is inclined in the other direction to that shown the discharge and suction slots and pipes are interchanged.

If the two pipes from the slotted plate G are connected to the corresponding slotted plate of a similar mechanism, the latter will have its shaft rotated, becoming a hydraulic motor driven by the first. If in the second mechanism the part corresponding to D is at a fixed inclination, the revolutions of its shaft will vary in number and direction with the inclination of the tray D in the first mechanism. If D is vertical, the shaft of the second mechanism will not rotate; if D is placed on one side of the vertical the shaft will move in the same direction as that of the first; and if D is in the other side of the vertical, in the opposite direction. Used thus, it is a speed gear, and the revolutions of the motor end can be varied in direction and number

Several applications of the gear are shown in Messrs. Vickers' exhibit. The breech mechanism of the 16-in. naval gun is entirely operated by a small A end, used as a pump, and driven by an electric motor. As a speed gear, it is shown fitted to a 3-ton electric capstan, the motor with A and B ends being fitted below the level at which the capstan is worked, control being carried out by a foot lever by the operator. It is also being used for boat and cargo winches. For work in which very small motions are required as in slightly altering the angle of training of a gun turret the gear is well adapted and is used in many foreign warships. A well finished model of an electric hydraulic steering gear showing an A end used as a pump is also exhibited, and Fig. 8 shows such an application more compactly arranged than in the model. In this, four hydraulic rams are fitted, a pair on each side of the middle line of the ship and in the fore and aft line. The two electric motors and A ends—one being a stand by—are

mounted on the foremost pair of cylinders. The rudder crosshead is transverse, symmetrically situated between the four cylinders and moves in trunnions mounted on the ends of the connected rams of contiguous cylinders. The inclined plates of the two A ends are operated by telemotor gear from the bridge of the ship or from any other position desired. Similar gears have been fitted in foreign warships, and are being fitted in British war vessels. The speed gear has been applied in submarines fitted with screw-steering gear, the actuating screw being rotated by a B-end driven by an A end and electric motor. Units have recently been supplied to the Swedish Government for operating guns in coast defence ships and for submarines.

NOTES.

The International Foundry Trades Exhibition.

The experiment of holding an International Foundry Trades Exhibition in Birmingham in 1922 proved so successful that the Birmingham Chamber of Commerce decided to repeat the effort this year. This second exhibition was opened at Bingley Hall, Birmingham, yesterday, by Mr. R. O. Patterson, the President of the Institution of British Foundrymen, a Society which, with the Cast Iron Research Association, was associated with the Chamber of Commerce in organising the show. A very comprehensive display is provided of the machines and materials used in modern moulding practice, and there are some examples that have not previously been exhibited. Demonstrations are given on many stands of moulding with the various types of machines, designed to reduce works costs by the elimination of waste time. In contrast to the common type of roll-over or jarring machine, there is available for inspection in operation a "sand slinger," which travels into the sand heap on a foundry floor under its own power, collecting the sand at the centre of the machine by means of a right- and left-hand sand cutting screw conveyor, and raising it by means of a bucket elevator and deposit it upon the screen of an oscillating riddle. The material which passes through is discharged on to a belt, which carries it into the impelling head from which the sand is thrown out with considerable force by a system of rotating paddles. This machine was designed to fill moulding-boxes, and while filling them to introduce the sand in such a way as makes hand ramming quite unnecessary. We hope to describe in greater detail this and other outstanding items in what is an excellent show. It should be mentioned that a series of papers are to be read in the lecture hall attached to the exhibition. On Wednesday evening, June 25, Mr. Horace J. Young will present a paper on "A Comment Upon the Methods of Judging and Mixing Pig-Irons." On the next day two papers will be given: Mr. Robert Buchanan will lecture on "The Problem of the Liquid Contraction of Grey Cast Iron" in the afternoon, and Mr. E. Harwood Brown will speak on "Economy in Foundry Practice," in the evening. A paper on "Porosity in Cast Iron" will be read by Mr. Arthur Marks, on Friday, June 27. Other papers are in contemplation, and a series of competitions for foundry employees will also be held. The exhibition will remain open until Saturday, June 28.

The Glow of Phosphorus.

Lord Rayleigh showed at the Royal Institution recently that the study of the "Glow of Phosphorus" was beset with pitfalls. That the glow is due to a slow oxidation of the phosphorus has long been understood. But oxidation seemed sometimes to fail in Lord Rayleigh's striking experiments, old and new. A solution of phosphorus had been placed in a glass flask which was filled with pure oxygen; there was no glow at all, until the oxygen was rarified by means of a pump; then the glow appeared suddenly, to disappear again on readmission of the oxygen. Exposed to the air in a tray the phosphorus solution phosphoresced brightly; but heavy vapours of carbon bisulphide, descending upon the tray, at once extinguished the glow, which reappeared when Lord Rayleigh blew upon the surface. Vapours of camphor and many organic compounds, also ammonia and water vapour, inhibited the glow. A cylinder of glass, containing phosphorus, some camphor vapour and air, did not glow, but more air slowly diffusing into the cylinder through a long capillary caused pulses of luminous clouds to travel along the cylinder at adjustable intervals of a second or so. Some years ago L. and E. Bloch observed that the glow over a slab of solid phosphorus could be detached from that surface and be removed to a distance by blowing oxygen or air along the surface. Lord Rayleigh found a key to the peculiarities of the glow by conducting these and similar experiments at different gas velocities, oxygen concentration and temperatures, &c. At — 20 deg. C. the slab was itself dark; at higher temperatures the glow would appear, though it was mostly so faint that it required exposures of 2 and 4 hours to photograph it. An air blast would remove the glow from the surface, a luminous cloud or succession of clouds appearing at some distance. The velocity of blast necessary to remove the luminosity increased greatly with rise of temperature (1,000 times with a rise from 0 deg. C. to 15 deg. C.). It was much decreased by enriching the oxygen. The luminosity, Lord Rayleigh suggested in explanation of the peculiarities, was due to the oxidation of phosphorus vapour; very little oxygen sufficed for starting it, and very little heat was liberated by the reaction. Hence the oxidation would not be propagated by the heat of the reaction as in an explosion. But the oxidation yielded solid phosphoric acid, which acted as a catalyst, unless inhibitory substances (catalytic poisons) like ammonia, water or oxygen, itself condensed upon it and stopped the propagation of the reaction. Air currents, temporarily removing the poison and exposing fresh phosphorus surfaces, would tend to make the phenomena periodical.

British Iron and Steel Production.—The National Federation of Iron and Steel Manufacturers report that the British production of pig-iron in May amounted to 650,900 tons, compared with 618,400 tons in April and 714,200 tons in May, 1923. The number of furnaces in blast at the end of the month was 191, a reduction of three since the beginning of the month. The output of steel ingots and castings in May amounted to 809,700 tons, compared with 711,500 tons in April (when production was affected by the Easter holidays) and 821,000 tons in May, 1923.

World Power Conference.—The American Committee of the World Power Conference states that over 200 of the leading mechanical, electrical, civil, and marine engineers of the United States are sailing on June 19 on the ss. Scythia to attend the conference to be held in London, from June 30 to July 12, in connection with the British Empire Exhibition. Presenting 37 papers of their own, and prepared to take part in the discussion of the hundreds of papers to be presented by engineers from 26 other countries, the American delegates will give their international associates full information on the latest developments in American methods. Eight technical, twelve business, and nine Government organisations interested in power development will be represented.

Personal.—Mr. Percy Griffith, M.Inst.C.E., states that as from the 24th inst., his offices will be situated on the ground floor of No. 39, Victoria-street, S.W.1, his new telephone number being Victoria 6011.—Mr. A. L. Miéville is relinquishing the general managership of Messrs. Robert Morris and Co., of Farnworth, Colliery Engineers, to become the General Manager of the Howden-Ljungström Preheaters (Land) Limited, at Govan.—Mr. Claude M. Toplis, inventor of the Toplis level luffing crane, has resigned his position with Messrs. Stothert and Pitt Limited, and taken a partnership in the Bedford Engineering Company, Bedford.

The Whitworth Society.—This society will hold a dinner in the Caledonian Salon of the Holborn Restaurant, London, at 7 p.m., on Tuesday, July 8. The members will be received by the President, Dr. H. S. Hele-Shaw, F.R.S., at 6.30 p.m., and it is hoped that there will be a large attendance. Immediate application should be made for tickets and no seats can be guaranteed after July 1. The price is 10s. each. Morning dress will be worn and, as has been the practice at other Whitworth Society gatherings, no guests are eligible. The retiring president will induct the new president, Mr. R. B. Buckley, C.S.I., the Senior Whitworth Scholar, into the chair. Tickets may be obtained from Mr. E. R. Dolby, the hon. secretary of the Whitworth Society, at the Institution of Mechanical Engineers, Storey's Gate, Westminster, S.W. 1. It is much to be hoped that those who are eligible for membership of the society and are not yet members will make this opportunity for joining.

THE LATE DR. R. M. WALMSLEY.

A figure very well known in connection with engineering education has been removed by the death of Dr. Robert Mullineux Walmsley, Principal of the Northampton Polytechnic Institute, John-street, Clerkenwell, London, E.C. 1. Dr. Walmsley died last Sunday as the result of a street accident, being knocked down by a car as he was walking to his home on Friday evening. He suffered from concussion and a broken ankle, and was taken to the Royal Northern Hospital. An operation was performed on Saturday, but he died the next morning without regaining consciousness.

Dr. Walmsley, who was born near Liverpool, had been connected with technical education during practically the whole of his working life. He was educated at a private school and at Queen's College, Liverpool, and matriculated at the University of London in 1879. He obtained his B.Sc. in 1882 and his D.Sc. in 1886.

During his professional career Dr. Walmsley was first engaged in connection with secondary education, and later as a technical assistant to Professors Ayrton and Perry. He was appointed Senior Demonstrator in Electrical Engineering at the Finsbury Technical College in 1883. In 1887 he went to India as Principal of the Sind Arts College of the University of Bombay, but returned to England the following year, and after spending a year as a member of the staff of the City and Guilds (Engineering) College, became First Professor of Electrical Engineering and Applied Physics at the Heriot-Watt College, Edinburgh. He retained this position for some five years, and in 1896 became Principal and Head of the Electrical Engineering Department of the Northampton Polytechnic Institute—a post he held until his death. Dr. Walmsley was Chairman of Convocation and a Senator of the University of London, and had held many similar positions. He was for 15 years Chairman of the University Extension Board, and was Chairman of the Council of the Association of Technical Institutions in 1909, Chairman of the Executive Committee of the Optical Convention in 1912. He had been a member of council of the Royal Aeronautical Society of Great Britain, and was a member of the Institution of Electrical Engineers and a Fellow of the Institute of Physics.

In addition to his educational activities Dr. Walmsley did some consulting work, and his name was familiar to a very wide circle by some of his published work, particularly his well-known "Electricity in the Service of Man." This was based on Dr. Urbantizsky's book of the same name, the second edition of which Dr. Walmsley partly revised and greatly extended. He later, in 1904, entirely re-wrote and greatly extended the book, which since has passed through many editions.

THE "OXFORD" DISTRIBUTOR FOR ASPHALT COLD SPRAY.

Messrs. John Allen and Sons (Oxford), Limited, of Cowley, Oxford, have recently brought out a small distributing machine for the application of asphalt "cold spray" to road surfaces. The machine consists of a low rectangular tank on small wheels. The axle of the rear wheels is fixed to the tank, while at the front end a swivelling fore-carriage is provided with a handle by which the appliance can be hauled about by a man. A short ramp enables a barrel of cold spray to be rolled from the ground up on to the tank, where it rests on four rollers so that it may be easily turned round in order to get the bung-hole in a suitable position for emptying into the tank. At the front a shield is fitted to prevent the issuing liquid splashing over the tank end. At the rear a sluice-gate is arranged, operated to fine adjustment by a screw and hand-wheel within reach of the man at the draw-bar. The gate can be adjusted to any suitable flow, and the coating distributed is stated to be very uniform. The gate can be promptly shut if occasion should arise.

The tank holds 40 gallons, and asphalt cold spray can be distributed at any rate between from 5 gallons to 10 gallons per super-yard with but little practice, according to the nature of the surface. As a rule the barrels, after emptying into the container, are removed from the machine, to facilitate hauling. In the process of treating a surface the distributed material is worked in by two men with stiff brooms.

Empire Automobile Conference.—An Empire Automobile Conference, under the joint auspices of the Society of Motor Manufacturers and Traders and the Institution of Automobile Engineers, will take place on Monday next, the 23rd inst., in No. 3 Conference Hall at Wembley Exhibition. There will be two sessions, commencing at 11.30 a.m. and at 3 p.m. Two papers are to be read and discussed, on "The Requirements of the Colonial Market: the Technical Aspect," and "The Overseas Automobile Market: the Commercial Aspect."

THE DEVELOPMENT OF THE MARINE DIESEL ENGINE.

AN important announcement on this subject was made by Mr. D. B. Morison, as Chairman of Messrs. Richardson, Westgarth and Co., Limited, at the annual meeting of the company, held at West Hartlepool on Tuesday. He said that, with the object of ensuring sustained progress, especially in the direction of greater power per cylinder, with correspondingly reduced weight and initial cost, the directors were considering a scheme by which Messrs. Tosi (Italy) Messrs. Beardmore, Messrs. Furness Withy, and Messrs. Richardsons, Westgarth would collectively design and exhaustively test one or more types of marine oil engines, based on the combined experience of the several companies. It was, he remarked, surely a good augury for the future to find such progressive and eminent authorities as Lord Invernairn and Sir Frederick Lewis combining their experiences in shipbuilding and shipowning with those of Messrs. Beardmore, Messrs. Tosi, and Messrs. Richardsons, Westgarth, on the engineering side, in an endeavour to effect the more rapid solution of the vital question of reducing the first cost of what promised to be the dominating means of ship propulsion in the future.

INDUSTRIAL NOTES.

OWING to the energetic action taken by the London Underground Railways, the Great Western Railway and the National Union of Railwaymen, the unofficial strike of a number of men employed on the above systems came to a close last Friday, and train services have since returned to normal.

It was announced when we went to press with our last issue that a ballot of members of the Associated Society of Locomotive Engineers and Firemen was soon to be taken in the matter of classification and Sunday duty. Mr. J. Bromley, general secretary of the Society, stated a few days later that whilst a ballot was "more or less inevitable," the executive before proceeding further with the matter would await the final word of the railway managers. He pointed out that although the railway managers would not give way on the main principles put forward by the Society, they were prepared to go into various details with a view to easing the situation if possible. Therefore, before the Society's executive drew up the terms of the ballot paper, they would require to know exactly what the railway companies intended to do. As reported in our last issue these two points, amongst others, were fully accepted by the National Wages Board, on which the Society was fully represented. The award of the Board led to the termination of the recent enginemen's and firemen's strike, and, if we remember well, Mr. Bromley hailed the decision then arrived at as a complete victory gained by his Society. That disputes should now arise on points which were agreed upon is to say the least most disconcerting. The latest reports are to the effect that following a meeting of the Society held on Wednesday, the ballot papers are to be issued to all the branches next week; they are returnable on July 15. This decision was taken owing to the reply received from the railway managers not being found to concede the full desires of the Society's delegates. There is apparently some tendency to suggest that the railway companies are not keeping to the agreement.

A settlement has now been arrived at in the matter of the Leith coal trimmers' strike, our last reference to which was on page 670 *ante*. The strike lasted thirteen weeks, and at one time threatened to involve all the coal exporting ports throughout the country. A conference was held last week-end between representatives of the Leith employers and of the men's unions concerned, at the close of which it was officially stated that an agreement had been reached. The trimmers were to resume work to-day.

Cumberland iron miners' wages are reduced following the fall in the monthly ascertainment price of Cumberland hematite iron mixed numbers, which showed a reduction of about 10·49*d.*, from 5*l.* 1*s.* 8·22*d.* to 5*l.* 0*s.* 9·73. As will be seen, the decrease in wages is but slight; it will last until the middle of next month, the principal new rates being as follows (per day or shift in each instance):—Miners working bargains 10*s.* 1*d.*; miners minimum, 7*s.* 5*d.*; underground, labourers, 6*s.* 5*d.*; blacksmiths, 9*s.* 2*d.*; chargemen, mineral shot borers, and joiners, 9*s.* 2*d.* (plus allowance for tools, &c.); winding enginemen, 8*s.* 9½*d.*

A joint meeting of the representatives of the building trades employers and operatives was held last Monday, following the ballot, referred to in our issue of the 6th inst., which gave a majority for accepting the employers' terms. At the close of the meeting it was stated that a settlement had been arrived at on the national wages question, involving a half-penny per hour increase to all sections of the industry, to apply immediately. The joint secretaries of the Negotiating Committee, Mr. A. D. White for the employers and Mr. R. Coppock for the men, are now drawing up the full terms of the settlement, which will be signed when completed. The adverse action on the part of the building trades operatives on the Merseyside, which we mentioned in our issue of the 6th inst., still bars the way to a complete settlement. The Merseyside difficulty, it is reported, is due to the action of the local employers who hitherto had stood apart from the Building Employers' Federation and had a higher scale of wages than the London one. On their deciding to adopt the national scale of pay, the men declined to agree to the reduction this involved in their wages.

Dealing with the recommendations of the Dawes committee on the reparations to be paid by Germany to the Allies, *The Iron Age*, New York, says that in the first place Germany must be financed, in which connection the United States must bear the brunt of the burden; it can do so and will want to. Our contemporary then gives the consequences of Germany's forthcoming regular participation in the world's markets, following upon her renewed industrial activity. "We may," it adds, "exclude her to a greater or less extent from the United States by means of our tariff, but we may lose correspondingly in our own export trade wherein we have no protection and are on a purely competitive basis. For example, while we are selling to Germany more copper in wire bars, we may find that we are selling less copper to the rest of the world in the form of wire." The American journal, in the same article, says that the greatest question with relation to German reparations is as to whether the new conditions are going to solve the problem of unemployed labour in Great Britain, where about 10 per cent. of the workers are continuously idle and are supported by doles at the expense of the more well-to-do people. "There is a grave question whether the British workman has not been so spoiled by that pernicious system that he is no longer disposed to work even if he has the opportunity."

The new agreement regulating the wages in the coal mining industry referred to in our issue of the 6th inst. was signed at a joint meeting held on Wednesday of representatives of the Mining Association and the Miners' Federation.

The Ministry of Labour states that employment showed a further improvement during May. Among the 11,500,000 workpeople insured under the Unemployment Insurance Acts in Great Britain and Northern Ireland, the percentage unemployed on May 26 was 9·5, compared with 9·7 on April 28 and with 11·2 in May, 1923. Among members of trade unions from which returns were received the percentage unemployed was 7 at the end of May, compared with 7·5 at the end of April. The total number of applicants for employment registered on May 26 at Employment Exchanges in Great Britain and Northern Ireland was approximately 1,022,000, of whom 767,000 were men and 191,000 were women, the remainder being boys and girls; on April 28 the total was 1,052,000.

Employment was good in the coal-mining, tinplate and steel sheet, carpet and jute trades, and with brickmakers, coachbuilders, and skilled workmen in the building trades; it was fairly good in the woollen and worsted industry and in certain branches of the metal and clothing trades; and fair in the printing and furnishing trades. In some other large industries, however, including iron and steel manufacture, engineering and shipbuilding, it continued slack.

The upward movement in wages continued in May. In the industries for which statistics are available the changes in rates of wages reported during the month resulted in an aggregate increase of about 275,000*l.* in the weekly full-time wages of about 1,350,000 workpeople, and in an aggregate reduction of about 3,700*l.* in those of 45,000 workpeople. The principal increases resulted from the adoption of the new agreement in the coal-mining industry, by which the general level of wages was advanced in the principal districts by amounts varying from 3 per cent. to 12 per cent. on current rates, and additional increases were granted to the lower-paid workers in most districts. There was an increase of about 1 per cent. on the current rates of steel smelters and millmen in various districts in England and Scotland, and other important groups of workpeople whose wages were increased included ship repairers on the Thames and Mersey, men employed in the lead-manufacturing industry, vehicle builders, and road-transport workers in several large towns in Yorkshire and Lancashire. The principal bodies of workpeople who sustained reductions in wages were metallic bedstead makers, pen-makers at Birmingham, and furniture trade operatives and road-transport workers in Scotland. During the first five months of 1924 the changes in rates of wages reported to the Labour Department have resulted in net increases amounting to about 480,000*l.* in the weekly full-time wages of 2,480,000 workpeople, and in net reductions of 13,500*l.* in the weekly wages of nearly 250,000 workpeople. In the corresponding period of 1923 there were net reductions amounting to 340,000*l.* in the weekly full-time wages of 2,350,000 workpeople, and net increases of over 100,000*l.* in the weekly wages of 760,000 workpeople.

There was a slight decline, on the average, in working-class cost of living during May, mainly due to reductions in the prices of food and coal. On May 31 the average level of retail prices of the commodities taken into account in the statistics compiled by the Ministry of Labour was approximately 69 per cent. above that of July, 1914, as compared with 71 per cent. on May 1 and with 69 per cent. on June 1, 1923.

The number of trade disputes involving stoppages of work, reported to the Department as beginning in May, was 56. In addition, 30 disputes which began before May were still in progress at the beginning of the month. The total number of workpeople involved in all disputes in May was approximately 36,000, as compared with 51,000 in the previous month. The estimated aggregate duration of all disputes during May was about 398,000 working days, as compared with 471,000 days in April. During the first five months of 1924 the stoppages of work owing to trade disputes, so far as reported to the Department, have involved approximately 356,000 workpeople, as compared with 221,000 workpeople involved in disputes in the first five months of last year. The aggregate duration of the stoppages in January to May, 1924, has been nearly 3,000,000 working days, as compared with approximately 3,100,000 days in the corresponding period of 1923.

AIRCRAFT FABRICS.

AMONG the large number of papers contributed to the general discussion on "Physical and Physico-chemical Problems relating to Textile Fibres," held on June 11, at the British Empire Exhibition by the Faraday Society and the Textile Institute, was one by Mr. J. E. Ramsbottom, of the Royal Aircraft Establishment, Farnborough, on "Aircraft Fabrics." The paper gave interesting information on the testing of the fabrics.

The fabrics employed for the structural covering of aircraft, Mr. Ramsbottom pointed out, were never used in the untreated condition, but were coated with a cellulose-ester solution (a dope) to produce a taut, air-tight and watertight surface of light weight. Tautness denoted the property of a stretched cover by virtue of which it resisted depression by means of normally-acting forces. To obtain comparative measurements, loaded spheres were placed on the fabric which was fixed on rigid frames of standard dimensions; the depressions would then primarily depend on the dope, and secondarily on closeness of weave, extensibility at low load, count of yarn and nature of fibre. To combine tautness with the minimum amount of dope, the nterstices between the threads of the fabric should be small; in this respect fabrics could be improved by calandering. At low humidity, linen, cotton and silk fabrics all showed satisfactory tautness. At high humidity they differed; cotton and linen lost part of their tautness, but after a while the contraction of the fibre due to water absorption predominated; with silk, the tautness fell off continuously until equilibrium was reached. For that reason silk was not used for aero covers in this country. The contractile power of mercerised cotton in very humid atmospheres was superior to that of unmercerised cotton and of linen. Relative values of the tautness, dry and after exposure for 1, 6 and 24 hours to a relative humidity of 95 per cent. were: linen, 4·5, 6·4, 7·4, 6·0; mercerised cotton, 4·3, 6·6, 7·0, 5·0; silk, 3·8, 6·7, 8·2, 10·1; these figures expressed the depression observed in millimetres under loads of 400 grammes.

The strength of a doped covering, depending mainly upon the fabric, was best measured by a bursting test, which approached the conditions of actual flight. In order to allow for accidental damage, or perforation by bullets, tests were also made on wounded specimens. The specimen was clamped on an oblong metal frame, the ratio of the sides corresponding to the fabric panels of the respective aeroplane. The fabric was arranged with the warp parallel to the longer side; the pressure was applied by means of water, and a thin rubber sheet was placed under the fabric. As the stress was mainly borne by the weft threads, cuts across the weft were the most dangerous. The following figures gave bursting pressures (in lb. per square inch) on a 3-in. by 12-in. panel,

for unwounded and wounded specimens with ½-in. and 1-in. wounds cut across the weft: linen, 52½, 13 7; mercerised cotton, 70, 15½, 8¾; cotton, 60, 13¾ 7½; silk, 78, 19, 13¾. Rip tests were also made; in these cotton and silk were inferior to linen. Greater bursting strength could be obtained by employing yarns coarser than those now in use.

As regards weathering and seasonal influences, it was found at Farnborough that linen fabrics treated with clear acetyl-cellulose lost by exposure for one month in January, 5 per cent. and in July, 45 per cent. of their strength. The relative losses in the strength of cotton, linen and silk were as 4 : 6 : 10. The chief factor in that deterioration was the sunlight. Exposures through glasses of various colours reduced the strength of doped linen, originally 120 lb. per square inch, to 102 in red, 89 in green, 47 in blue-green, 14 in yellow, 8 in violet and 4 in blue light, and to 6 under clear glass; the glass, therefore, gave practically no protection at all, whilst red or orange light did little damage. In heat tests, conducted by keeping fabrics in a stove at 80 deg. to 100 deg. F. for 1,200 hours, the following strength losses were observed: linen, undoped, 24, doped, 23; mercerised cotton undoped, 2; silk undoped, 15; cotton undoped, 14. The figures would explain the superior results obtained with mercerised cotton in Egypt. Deterioration by organic growth seemed to be too slow to be of any practical importance.

Since light seemed to be the chief destructive agent, experiments had also been made on keeping the light out by dyeing the fabric, by using a flexible pigmented varnish and by introducing both pigments and dyes into the dope. Dyeing of linen afforded some protection, an opaque varnish proved more effective; in 2½ years' weathering tests, unprotected doped linen lost 93 per cent. in strength, linen covered with pigmented varnish, only 20 per cent. The introduction of pigments into the dopes, moreover, reduced the slackening in moist atmospheres, saved weight (as no varnish was wanted), and gave more uniform layers. Of the best pigments studied, yellow ochre, carbon black and red iron oxide, ½ oz. were wanted per sq. yard. For airship covers, the renewal of which was exceedingly costly, dyes were used in addition to pigments After two years' weathering specimens of linen with dyed and pigmented nitro dope and aluminium varnish, showed a strength loss of 3 per cent. only, whilst the linen with clear dope lost 92 per cent. and the pigmented nitro dope alone 11 per cent. With the use of protective coverings the differences between the rates of deterioration of linen, cotton and silk fabrics largely disappeared, though mercerised cotton generally gave the best results.

NOTES ON NEW BOOKS.

THE list of contributors to volume VIII of the "*Annual Reports of the Society of Chemical Industry on the Progress of Applied Chemistry*," dealing with the year 1923, comprises again a considerable number of new names, and the section on Explosives, which dropped out in 1922, makes its reappearance. Mr. T. F. Burton remains the editor, to whom we may be indebted for the excellent name and subject indexes which greatly add to the value of the compilation. In the Explosives section Mr. J. Weir does not record any outstanding advance, either in manufacture or application, and he speaks of there being little more than strenuous efforts to extend the use of liquid oxygen explosives; as regards solvent recovery, he considers cresol, activated charcoal and inorganic gels as the only absorbents of the future. Among the novelties to which Mr. J. H. West draws attention in the section on Plant and Machinery, are the Hele-Shaw streamline filter, the colloid mills of Plauson and Podszus, and the heat-pumps and evaporators of the Prache-Bouillon type. This section is much shorter than those on Fuel (Mr. E. C. Evans) and on Gas, Destructive Distillation and Tar Products (Messrs. F. M. Potter and D. Ivor James). They regret the trade depression but welcome the growing appreciation of the value of expert chemists. Dr. J. J. M. Auld, dealing with Mineral Oils, ascribes the "demoralisation of the oil market" to the over production of crude oil in the United States; small success had continued to attend the search for oil within the British Empire, notably in Queensland and South Africa. The sections on Iron, Steel, Non-ferrous Metals and Electrochemistry, as well as the section on Rubber, remains in the same hands; in the section on Sanitation and Water Purification, Mr. J. H. Johnston has succeeded Dr. Calvert. The report is published by the Society of Chemical Industry, Central House, Finsbury-square, E.C. [price 12*s.* 6*d.* to non-members].

On other occasions we have noticed four volumes of "*A Dictionary of Applied Chemistry*," edited by Sir Edward Thorpe, F.R.S. The new volume V [Longmans, Green and Co., price 60*s.* net] carries the matter from "oxygen" on to "rye." In this volume we find new noteworthy sections, on electrical dust and mist precipitation by Dr. H. J. Bush, on photosynthesis by Professors E. C. C. Baly and I.M. Heilbron, and on radiology by Sir William Bragg and Dr. E. A. Owen. On the other hand, the information given in the article on rubber concerning vulcanisation is scanty and not up to date, whilst the doubt which the most recent researches have thrown on the old-accepted formula for caoutchouc is duly mentioned. We have not seen any statement in the book that more on vulcanisation will follow under that heading. But it may be so, and for this and other reasons we reserve further comments.

Two volumes of recent publications belonging to the Sammlung Göschen, deal with engineering drawing and design. The title is "*Praktisches Maschinenzeichnen mit Einführung in die Maschinenlehre*," and the author is Professor W. Tochtermann, of Esslingen, who has re-written the late R. Schiffner's book of the same title. The small volumes will be found useful for students who are unacquainted with the practice and conventional symbols of the drawing office. Other books of the same series are Dr. Ing. L. Zipperer's "*Maschinenmesskunde*," an introductory treatise on engineering measurements, and Professor F. Sallinger's "*Gleichstrommaschine*," Part II (direct current dynamos and motors). These serviceable primers are published by Walter de Gruyter and Co., Berlin, at the price of 1·25 gold mark each.

It must now be some thirty years or more since M. d'Ocagne founded the science of nomography. It took a long time for the value of his work to be recognised, but to-day the great convenience of alignment charts is universally admitted, since without going to excessive dimensions the scales can generally be read with an accuracy sufficient for almost all practical needs. It is not surprising, accordingly, that many books explaining the principles on which these charts are based have been published during the past few years. Probably the principle of duality, according to which any proposition in plane geometry concerning points has an exactly corresponding proposition in which points are replaced by lines, affords the most readily intelligible basis for explaining the subject. In essentials, though the term duality is not mentioned, this is the method followed by Mr. W. J. Kearton and Mr. George Wood in their book on "*Alignment Charts for Engineers and Students*," which has just been published by Messrs. Charles Griffin and Co., Limited, at 16*s.* net. In this treatise principles and methods are explained in such great detail that a reader should not have difficulty in preparing any special charts he may require for his own use. The authors confine themselves to the conditions in which all the supports are straight lines, but these cover the vast majority of practically useful cases. An extensive selection of charts solving such engineering formulas as are of common use in the drawing office forms the concluding section of the volume. Folding plates have been used for many of these charts in order to obtain sufficiently open scales.

English text-books commonly commence with the consideration of a number of simple elementary problems and, as the student gradually familiarises himself with these, he is led on to general theory. This plan may perhaps be described as a synthetic presentation of the subject. A converse system of presentation is more popular in France, where the method frequently adopted is to start with certain general theorems from which the laws pertaining to particular problems are deduced. Both plans have their advantages. For the beginner the synthetic system is perhaps the best, but the alternative method has some considerable advantages for students who start a new subject with a fair knowledge of mathematics. To such of these as may be interested in alternating current problems, the little treatise on the "*Theorie Générale sur les courants Alternative*," just issued by Messrs. Gauthier-Villars et Cie., Paris, should prove particularly welcome. The author is M. E. Piernet, engineer to the Compagnie Française Thomson-Houston, and the subject is developed exceptionally clearly, although very concisely. For the most part this is accomplished without the aid of the complex variable, but a special chapter is devoted to showing how remarkably the introduction of the mathematical imaginary simplifies the discussion of alternating current phenomena.

The fourth edition of the "*Treatise on Hydrodynamics*," due to Professor Horace Lamb, F.R.S., acquired a thoroughly justified reputation as the treatise on this very difficult and abtruse subject. This position will be consolidated by the fifth edition, which has just been issued by the Cambridge University Press, at the price of 45*s.* net. As it happens most of the hydrodynamical problems with which engineers are concerned can either be reduced to the two dimensional type or have so far proved mathematically insoluble. It is very convenient, therefore, that Professor Lamb has grouped into one chapter much of what is known with respect to two dimensional flow. Reference is thus greatly facilitated. The sections dealing with the Lanchester-Prandtl theory of aeroplane lift and drag are, we believe, new. The theory of the viscous flow of fluids is steadily becoming of greater and greater practical importance, and about one-fifth of the text of the new edition is now devoted to this subject. A special word of commendation must be given to the University Press for the excellence of the printing and general get up of the volume.

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Analytical Mechanics. Comprising the Kinetics and Statics of Solids and Fluids. By EDWIN H. BARTON, D.Sc., F.R.S. Second edition. London: Longmans, Green and Co. [Price 21*s.* net.]

Spectroscopy. Vol. I. By E. C. C. BALY, C.B.E., M.Sc., F.R.S. Third edition. London: Longmans Green and Co. [Price 14*s.* net.]

Ministry of Public Works, Egypt. Physical Department Paper No. 13. *Report on Investigations into the Improvement of River Discharge Measurements. Part V.* By E. B. H. WADE, M.A., F.Inst.P. Cairo: Government Press. [Price PT. 10.]

Model Railways, Their Design, Details and Construction. By HENRY GREENLY. London: Cassell and Co., Limited. [Price 6*s.* net.]

Automatic Telephone Systems. Vol. III. Large Multi-Office Automatic Systems; Semi-Automatic Working; Miscellaneous Systems; Lay-out and Wiring; Power Plant; Traffic. By WILLIAM AITKEN, M.I.E.E. London: Ernest Benn, Limited. [Price 55*s.* net.]

The Modern Foreman. By ROBERT GRIMSHAW, M.E. New York: The Gregg Publishing Company.

Lehrbuch der Elektrotechnik, Vol. II. By ESSELBORN. Second edition. Leipzig: William Engelmann. [Price 24*s.* 6*d.*]

Handbook for Ozy-Acetylene Welders. By LEONARD M. FOX, M.I.Mech.E., M.I.Mar.E. London: Allen-Liversedge, Limited. [Price 1*s.* 6*d.*]

United States Bureau of Standards. Circular No. 145. *Summary of Technical Methods for the Utilization of Molasses Collated from Patent Literature.* [Price 15 cents.] No. 163. *United States Government Specification for Titanium Pigment, Dry and Paste.* [Price 5 cents.] Technologic Papers No. 251. *Equalizer Apparatus for Transverse Tests of Bricks.* By H. L. WHITTEMORE. [Price 10 cents.] Washington: Government Printing Office.

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Factory Management. By HENRY POST DUTTON, B.E.E. New York: The Macmillan Co. London: Macmillan and Co., Limited. [Price 14*s.* net.]

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Notes on Iron and Steel. By BRIG.-GEN. R. K. BAGNALL-WILD, C.M.G., C.B.E., M.I.Mech.E. London: His Majesty's Stationery Office. [Price 1*s.* 6*d.* net.]

United States Bureau of Standards. Circular No. 10. *Legal Weights (in pounds) per Bushel of various Commodities.* Fourth edition. [Price 5 cents.] No. 136. *United States Government Specification for Numbered Cotton Duck.* Second edition. [Price 5 cents.] No. 152. *Recommended Specification for Ceramic Whiting.* [Price 5 cents.] Washington: Government Printing Office.

Practical Calculus for Home Study. By CLAUDE J. PALMER. First edition. London: McGraw-Hill Publishing Company, Limited. [Price 15*s.* net.]

Estimating Building Costs and Appraising Buildings. By FRANK E. BARNES, C.E. First edition. London: McGraw-Hill Publishing Company, Limited. [Price 25*s.* net.]

THE ASSOCIATION OF MINING ELECTRICAL ENGINEERS.—The annual meeting of the Association of Mining Electrical Engineers was held at the Midland Grand Hotel, St. Pancras, London, from Tuesday, June 10, to Friday, June 13. Conducted visits were made to the British Empire Exhibition on Wednesday and Thursday. On Friday afternoon Mr. George Raw delivered his presidential address, taking as his subject "Steam and Electricity in Colliery Practice." On Friday evening the annual dinner was held in the Midland Grand Hotel when the president occupied the chair. Among the 150 members and guests present were Mr. W. W. Lackie and Mr. Archibald Page, of the Electricity Commission Mr. E. T. Foley and Mr. J. A. B. Horsley, of the Mines Department; and Mr. W. T. Anderson, Mr. A. B. Muirhead, Mr. E. Dinsdale Phillips and Mr. J. R. Cowie.

"PROTO" MINE-RESCUE APPARATUS AT THE BRITISH EMPIRE EXHIBITION.

CONSTRUCTED BY MESSRS. SIEBE, GORMAN AND CO., LIMITED, ENGINEERS, LONDON.

FIG. 1.

FIG. 2.

FIG. 3.

FIGS. 1 TO 3. FRONT, BACK AND SIDE VIEWS OF APPARATUS IN USE.

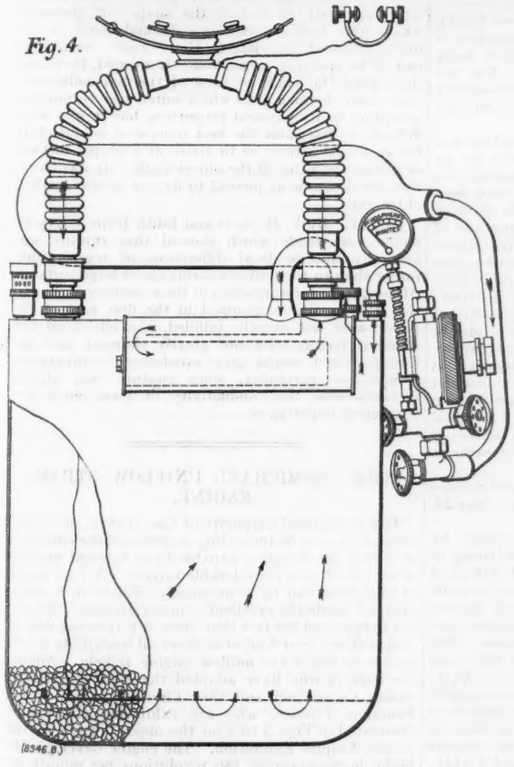
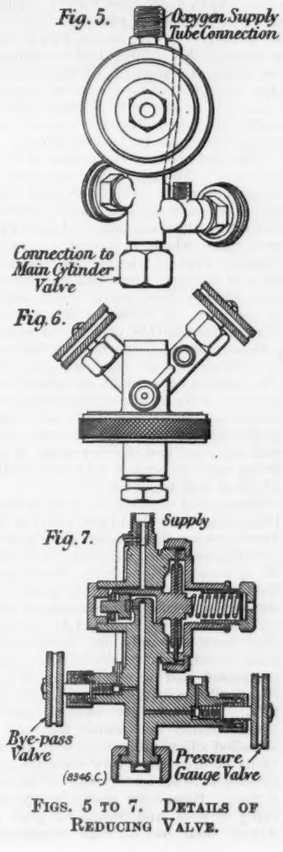


FIG. 4. DIAGRAM SHOWING ARRANGEMENT OF COMPONENTS.



FIGS. 5 TO 7. DETAILS OF REDUCING VALVE.

THE "PROTO" MINE-RESCUE APPARATUS.

AN important item included among the numerous interesting exhibits of Messrs. Siebe, Gorman and Company, Limited, 187, Westminster Bridge-road, S.E.1, in the Palace of Engineering at the British Empire Exhibition, is the "Proto" breathing apparatus for recovery and rescue work in mines after fires and explosions. The apparatus, of which Messrs. Siebe, Gorman are the manufacturers, is now well known and widely used both in this country and abroad. It has, in fact, been adopted by the principal mine-rescue stations throughout the world, as well as by numerous fire brigades, gas works, chemical factories, &c., where it is employed to enable work to be carried on in non-respirable atmospheres. The apparatus is made under the Fleuss-Davis patents and its latest form is illustrated in Figs. 1 to 7 annexed.

The makers' experience in the design of apparatus of this class is such that the particulars of its construction which we are now able to give will be followed with interest, but one important feature, viz., its compactness, will at once be apparent from Figs. 1, 2 and 3, which give front, back and side views of a man wearing the full equipment. It will be seen that the breathing bag is worn in front, while the oxygen cylinder fits into the hollow of the back, so that it projects as little as possible beyond the shoulders. As a result of this arrangement, a man wearing the apparatus can proceed along a low mine road or seam, and, if necessary, can crawl through an aperture only 15 in. square. The apparatus is carried by means of a strong leather and canvas harness, which fits over the shoulders and round the waist of the wearer. The total weight of the equipment, as illustrated and fully charged, is 37 lb., and this load is about equally divided between the front and back portions.

The general arrangement of the components of the apparatus is best shown in the diagram Fig. 4, in which the arrows indicate the direction of the flow of air and oxygen. It will, of course, be understood that, in this apparatus, a given quantity of air is breathed over and over again, the exhaled carbon dioxide being chemically absorbed, and the oxygen supply replenished from the cylinder. The wearer is provided with a mouthpiece shaped to fit between the lips and the gums, and with a clip which fits over the nose, so that respiration takes place by the mouth

only. The mouthpiece is connected by two corrugated rubber tubes to a breathing bag made of vulcanised indiarubber and protected by an outer bag of tanned canvas; the mouth of the bag is closed by metal clamps and wing nuts. The tube on the left of Fig. 4, carrying the exhaled air, is fitted with a light mica valve, which allows the air to pass into the bag but prevents it from returning in the opposite direction when the wearer inhales. Inside the bag is a rubber partition, which extends almost to the bottom, where the absorbent chemical, which is mainly caustic soda, is carried. The exhaled air travelling through the bag must thus pass down on one side of the partition, through the absorbent material which removes the carbon dioxide, and up on the other side. The purified air leaves the bag through an outlet at the top on the right-hand side and travels through an inverted U-tube into a metal container, in which it flows round an inner closed chamber filled with crystals of sodium phosphate. These crystals melt at 95 deg. F., and in melting cool the air, from which heat is absorbed to supply the latent heat of fusion. The sodium phosphate, it should be pointed out, does not require to be renewed, since it re-crystallises when the apparatus is out of use and the temperature falls sufficiently. Heat is, of course, radiated from the walls of the cooler if the temperature of the external atmosphere is lower than that of the air contained in the apparatus, but the cooling effect of the chemical is particularly useful when the apparatus is being used in a hot atmosphere. The air leaves the cooler through a valve opening outwards and returns to the mouthpiece through the corrugated tube on the right of Fig. 4, being continuously circulated in this way.

The oxygen cylinder contains 10 cub. ft. of gas compressed to a pressure of 120 atmospheres, and is connected by a steel tube, fitted with a main stop valve, to a reducing valve. Through this, the gas passes at atmospheric pressure into the breathing bag by way of an inverted U-tube connection. The valves and connections are clearly shown on the right of Fig. 4, and are also visible in Figs. 1 and 3, the latter illustrations indicating that the whole of the valves controlling the oxygen supply are located within easy reach of the wearer's left hand. Figs. 5 and 6 are an elevation and plan of the reducing valve drawn to a larger scale, while Fig. 7 is a longitudinal section illustrating its design and construction. The main stop valve is the lowest of the three shown on the right of Fig. 4, and this valve is connected by a union to the lower end of the body of the reducing valve. The gas flows up through a hole drilled in the valve body and escapes through a small pin hole on the left-hand side near the upper end, into a diaphragm chamber, as shown in Fig. 7. If the pressure in this chamber becomes excessive, the distention of the diaphragm causes a valve to move and close the pin-hole opening, the valve being directly connected to the diaphragm as shown in the illustration. The outward movement of the diaphragm, however, is opposed by a spring, the pressure of which can be adjusted by a hollow screwed plug. This arrangement enables the flow to be regulated, and it is actually adjusted to pass 2 litres of oxygen per minute, irrespective of the pressure in the cylinder. The gas flows from the diaphragm chamber to the breathing bag through a connection at the top of the valve body, but in order to provide against a possible failure of the reducing valve, a by-pass connection, shown on the left of Fig. 7, is fitted. This connection, which is controlled by a stop valve, enables oxygen to be supplied to the bag from the cylinder without passing through the reducing valve, as will be clear from an inspection of Fig. 7. A relief valve is fitted on the extreme left of the bag, as shown in Fig. 4, to prevent the pressure from becoming excessive, due to the injudicious use of the by-pass valve. The third valve, shown on the right of Fig. 7, controls a connection to a pressure gauge, which is carried on a flexible tube, seen in Fig. 4, and is used from time to time to indicate the pressure of the gas in the cylinder. The gauge is graduated in units of 10 atmospheres, and, at the normal rate of flow, the position of the pointer on the scale indicates the number of periods, of 10 minutes' duration each, for which the oxygen supply will still suffice. When the cylinder is fully charged, the oxygen supply is sufficient for two hours' work.

Various types of goggles and masks, one of which is illustrated in Figs. 1 to 3, can be provided for use when the apparatus has to be employed in smoke or in gases which affect the eyes, and the same illustrations show the method of securing the mouthpiece. In concluding our description of the apparatus, we may call attention to the advantages of carrying the absorbent material in the bottom of the breathing bag. Firstly, the material can be easily emptied out and replaced after use, the operation only occupying two or three minutes, and, secondly, the material is constantly stirred by the movements of the wearer in walking or working, and this has the effect of rubbing off the carbonated surfaces of the granules and exposing fresh surfaces to the chemical action. We may also mention that the bag is so constructed that the passages through it cannot be closed by external pressure; the wearer can, in fact, breathe quite freely when lying flat on the bag.

SOCIETY OF GLASS TECHNOLOGY.

DURING the last week of May a party of some 20 members of the Chambre Syndicale des Maitres de Verreries de France paid a visit to England at the invitation of the Society of Glass Technology.

During the week two meetings were held. The first in University College, London, on Tuesday, May 27, was a joint meeting with the British Society of Master Glass Painters. Three papers were presented. The first by Dr. Ethel Mellor, on "*The Decay of Window Glass from the Point of View of Lichenous Growths*," gave an interesting account of the acceleration of the decay of glass in ancient stained glass windows by the growth of lichens which made their habitat on the glass.

The second paper by Mr. Noel Heaton, on "*The Decay of Mediæval Stained Glass*," referred to the wide variations in resistance to decay found in mediæval stained glass. The author considered that this was to be attributed mainly to variations in the composition and physical structure of the glass used.

Window glass was introduced by the Romans, who arrived at a very sound composition, and their glass was remarkably durable. Analyses of glass of different periods revealed the differences in composition which resulted from a departure from the Roman tradition in mediæval times. The lowest ebb was reached about the end of the fourteenth century, one of the most notable examples being the glass of York Minster. In the process of decay two causes operated simultaneously: surface weathering due to atmospheric action, and well-defined pitting due to the structure of the glass. The variation found in stained glass of the same period was attributed mainly to primitive methods of manufacture, with certain affecting causes. It was characteristic of mediæval glass that the painted portions resisted decay better than the glass itself, which might be attributed to the lead silicate used uniting with the glass to form a more durable composition. The reverse was the case in later times, the enamel often perishing whilst the glass remained sound.

The last paper was "*The Weathering and Decay of Glass*," by Prof. W. E. S. Turner. The author said that ancient observers attributed decay to various causes. As recently as 1879, James Fowler in his well-known treatise on this subject made a minute examination of the decay of glasses of different epochs without being able to come to any precise conclusion. But the nature of the corrosion of glass had been methodically studied by the physical chemist, and the principal causes were now fairly well known.

The chief agent of the action of the atmosphere was moisture. All glass-ware absorbed moisture to an extent dependent in the first place on its composition, but partly also on the manner in which it had been treated by the workman. Glasses with little stability were those which contained excessive proportions of alkaline oxides, whether of sodium or potassium. Glass of the type, silica-soda-lime (such as window glass and ordinary sheet glass) which contained more than 18 per cent. of sodium oxide too readily decayed; at the same time the presence of at least 2 per cent. of potassium oxide permitted the total alkaline oxides to be increased to 20 per cent. without serious danger. The components which increased the resistance to decay of ordinary glasses were silica, lime, alumina and magnesia. Boric oxide was also very beneficial in a proportion of less than 12 per cent. The eventual hollowing out and the furrowing of glass in process of decay were associated with the mechanical treatment which it had received.

The second meeting was held in the Applied Science Department, Sheffield University, on Thursday, May 29. The following three papers were presented:—

"*Alumino-Silica Minerals in Fired Glass Pots*," by W. J. Rees. Messrs. N. L. Bowen and J. W. Greig, of the Geophysical Laboratory, Washington, U.S.A., had recently revised the investigations provisionally made on the binary system $Al_2O_3 : SiO_2$. They showed that there was only one compound of alumina and silica which was stable at high temperatures. This compound had a composition $3\,Al_2O_3$, $2\,SiO_2$, and chemically was quite distinct from sillimanite (Al_2O_3, SiO_2), although its optical and crystallographic characteristics were almost the same. The crystals of so-called sillimanite which were found in the different kinds of fired refractory material and in the ceramic articles were always crystals of the compound $3\,Al_2O_3$, $2\,SiO_2$. Researches made by the author during the firing of pots, and blocks for glass works, as well as during their use at high temperature, corroborated the results obtained by Bowen and Greig. The proportion of $3Al_2O_3.2SiO_2$ which were found in refractory materials after firing depended upon the composition of the material, upon the degree and duration of the heating, and upon contact with, or absorption of, siliceous matter such as glass.

"*The Effect of Various Constituents on the Viscosity of Glass*." By S. English. To the glass manufacturer, the viscosity of molten glass was perhaps the most important of its properties, as it was the viscosity and the way in which it varied with alteration of temperature that determined whether a glass could be satisfactorily melted and worked. Though the importance of this property has been realised, the practical difficulties of measuring the viscosity at temperatures up to 1,400 has prevented the subject being systematically investigated. Results have been published of only a few determinations, and the data provided do not always appear to be consistent. Of the various methods which have been used or suggested for the determination of the viscosity of liquids, the "rotation" method seems to be the most useful for glass, as it can be used over such a large range of viscosity. In applying this method, the glass was melted from cullet in a standard sized cylindrical crucible, and an iridio-platinum sheath secured on the end of a porcelain rod was rotated on its own axis in the centre of the crucible of glass. The time required for the iridio-platinum sheath to complete one rotation under different loads at various temperatures was determined, and the viscosity was given as a function of the product of the net effective pull and the time of rotation. The apparatus was calibrated by using syrup, the viscosity of which had been previously determined. The glasses used consisted of a series soda-lime-silicates obtained by a molecular substitution of lime for sodium oxide in a simple sodium silicate, and a similar series in which the sodium oxide was substituted by magnesia. The curves for the viscosities from about 750 deg. C. to 1,400 deg. C. show the way in which the viscosity is increased by substitution, and decreased by a rise of temperature.

"*The Thermal Endurance of Glass*," Part I, by V. H. Stott. In spite of its practical importance, the theory of the thermal endurance of isotropic bodies had been somewhat neglected. A theory was submitted, which, however, owing to the complexity of the phenomena involved, was necessarily not entirely satisfactory. Actually it was possible to increase the thermal endurance of glass by a suitable thermal treatment, but a general method for effecting this could not be given. Another question of practical utility, which could not be determined in a general way, was that of finding the shapes of glassware which were most resistant to thermal shock in the limits imposed by usage. Here, again, each case had to be specially considered. It seemed, therefore, that, from the point of view of thermal endurance, they could choose a glass which suited a given purpose according to its physical properties, but it was most difficult to determine the best process of manufacture for an actual article, or to arrive at a proper method of testing the value of the object made. It was therefore not desirable at present to fix any formal method of testing.

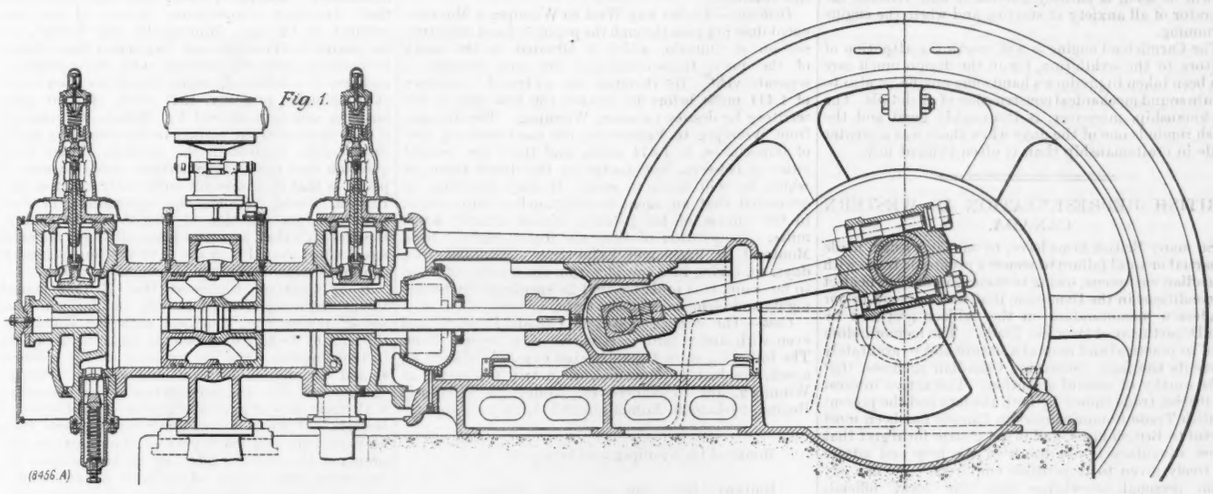
Part II. By V. H. Stott and Edith Irvine. Experiments were made which showed that rupture was generally due to local differences of temperature, rather than to the uniform shrinkage of large surfaces. Although this interpretation of the experiments showed that the conditions assumed in the first part of the paper were not strictly fulfilled, the effects of the different factors were not greatly changed, and the formula cited would give satisfactory comparative results. In particular, since rupture was almost instantaneous, the conductivity of glass could not have great importance.

THE CARMICHAEL UNIFLOW STEAM ENGINE.

THE mechanical simplicity of the uniflow, or central exhaust type of reciprocating engine, and the efficiency of which the design is capable have brought engines of this kind into considerable esteem. A long range of expansion can be economically utilised in a single cylinder, while the excellent cylinder drainage inherent in the type and the fact that there is no reverse flow of cooled steam over heated surfaces all contribute to the favour in which the uniflow engine is held. Among the makers who have adopted the type are Messrs. James Carmichael and Co., Limited, of the Ward Foundry, Dundee, who are exhibiting the engine illustrated in Figs. 1 to 4 on the opposite page, at the British Empire Exhibition. The engine develops 115 brake horse-power at 180 revolutions per minute, its cylinder having a bore of 15 in. and a stroke of 18 in. Like all of its kind, it works condensing, a jet condenser being fitted beneath it and the air-pump being operated

UNIFLOW STEAM ENGINE AT THE BRITISH EMPIRE EXHIBITION.

CONSTRUCTED BY MESSRS. JAMES CARMICHAEL AND CO., LIMITED, ENGINEERS, DUNDEE.



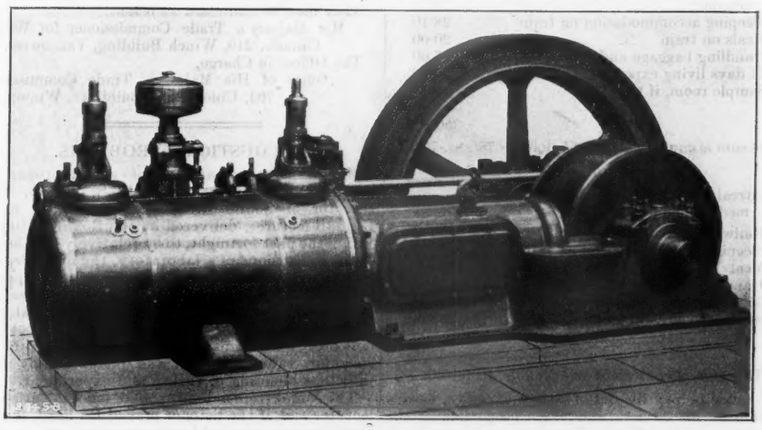
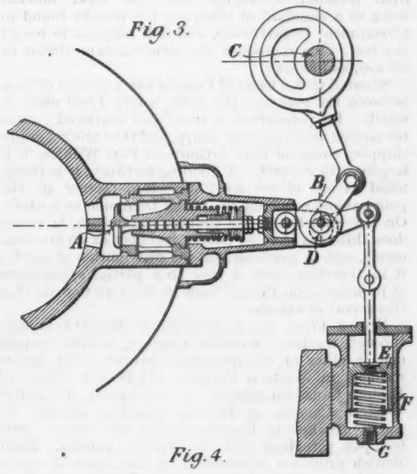
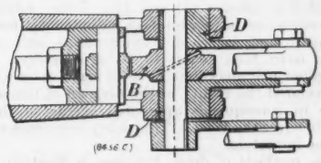


FIG. 2.





from the crankshaft. The condensing plant is not included in the Wembley plant, owing to lack of space.

The engine is very well finished and handsome in appearance. It follows modern practice in being totally enclosed and provided with forced lubrication, but much care and experimental work have been expended by the makers on the valve gear and governing mechanism. The governor is of the sensitive high-speed type and to obtain its full benefits, the controlling shafts are mounted throughout in ball or roller bearings. In all engines of the uniflow pattern some provision must be made for safety in case of the failure of the vacuum, for the ratio of compression is so high that should the exhaust pressure be much above that for which the engine was designed, the pressure at the end of the compression stroke would become a serious danger. The same conditions of course, obtain before the vacuum is established, when the engine is first started, but they can then be met by the use of hand-operated valves which open up a temporary addition to the clearance space. In the Carmichael engine an auxiliary exhaust valve is fitted at each end of the cylinder, which automatically controls the compression pressure and relieves the attendant of all responsibility with regard to the vacuum when running or starting up.

As regards the general design of the engine, the main bearings and crosshead slides are integral with the main frame. The frame rests on the foundations throughout practically its entire length, and as the metal of the casting forms the crank-pit, the foundations beneath are protected from the deteriorating effects of oil. With this also in view a continuous trough is cast around the edge of the frame. The trunk is connected to the cylinder by studs which pass through raised bosses, so as to minimise the conduction of heat from the cylinder to the frame. In the engine exhibited the cylinder is made in three parts, namely, the working barrel and the two steam-jacketted end sections carrying the steam and relief valves. The double-beat steam drop valves are light castings of special iron, and are guided between the seats of a rigid cast-iron cage. The cage carries the valve spindle guide and bonnet, thus ensuring the necessary alignment of the parts. The spindle, which is ground to size, and turned with grooves to prevent steam leakage, works in a long guide bush, without packing.

The piston is of a novel patented design. It consists of two halves screwed together to embrace a double-coned collar on the piston rod, which locates the complete piston in place. Other parallel collars turned on the piston rod support the outer ends of the piston and allow the latter free expansion while maintaining proper alignment. Two Ramsbottom rings are fitted to each end of the piston. The connecting rod has a split big end, with white metalled brasses and a solid small end. The crankshaft in the engine shown is machined from the solid with balanced crank webs. The main bearings have four-part "brasses" of cast iron, lined with white metal, provided with wedge adjustment. The layshaft is driven by enclosed spiral gearing and runs in ball bearings. From it are driven the steam valve operating gear, the auxiliary exhaust valve gear, the governor, cylinder lubricator and oil pump. The steam valve gear consists essentially of a bell crank on the valve bonnet, which receives its motion from a rolling cam driven by eccentric gear on the layshaft. An independent eccentric is employed for each valve, and has the inside strap extended to form a short eccentric rod, driving a swinging link with a variable point of suspension. A driving rod runs from the valve bonnet cam and connects with the eccentric rod at approximately a right angle. the lower end of this rod thus runs in an elliptic path, the inclination of which is controlled by the swinging link referred to above. The length of time the steam valve is open varies with the inclination of the path of the driving pin, and this in turn is determined by the action of the governor on the swinging link suspension.

The automatic auxiliary exhaust valve gear, which protects the engine in case of the failure of the vacuum, is illustrated in Figs. 3 and 4 above. At the side of the cylinder, at each end, is a horizontal mushroom valve A, normally held closed by a spring as shown. A sliding block attached to the end of the valve spindle carries a roller which, under certain conditions, is acted on by the cam B, thus opening the valve. By means of the eccentric and rod shown in Fig. 3, the cam B derives a rocking motion from the layshaft C, which runs alongside the cylinder. Reference to Fig. 4 will show that the cam is pinned to a spindle, to the end of which is keyed the lever attached to the end of the eccentric rod. The cam thus rocks synchronously with the motion of the engine. The bearings of the cam spindle are formed in eccentric bosses D of a pair of levers, the ends of which are linked to a spring-controlled piston E of a dashpot F. The space below the piston is connected at F to the condenser.

When the condenser vacuum is normal, the dashpot piston is in equilibrium in such a position that the cam rocks out of contact with the valve-roller, and the valve thus remains closed. Should the vacuum fail, the spring raises the piston E and causes the link-bosses D to rotate in the fixed lugs on the valve housing. This has the effect of bringing the cam-spindle nearer

the engine, with the result that during a certain part of every compression stroke the cam opens the auxiliary valve and so prevents the final compression pressure exceeding a pre-determined safe limit. The device, as will be seen, is entirely automatic and relieves the operator of all anxiety at starting and when the engine is running.

The Carmichael engine is well worth the attention of visitors to the exhibition, for in the design much care has been taken to produce a handsome engine, as also to ensure sound mechanical construction of all details. The workmanship, moreover, is thoroughly good and the finish reminds one of the days when there was a greater pride in craftsmanship than is often evident now.

BRITISH REPRESENTATION IN WESTERN CANADA.

So many British firms have, to our knowledge, made a partial or total failure to secure a profitable trade with Canadian customers, owing to their ignorance or neglect of conditions in the Dominion, that we commend to our readers a memorandum on the subject prepared by the Department of Overseas Trade. The memorandum is of so practical and helpful a nature and so accurately presents the facts concerning Canadian agencies, that it is worthy of careful attention. The active interest in British trade shown by both the late and the present British Trade Commissioners in Canada has been most useful to British firms, and it is a matter for regret that more advantage is not taken of the help and advice so freely given to responsible enquirers. We can say from personal knowledge that the local officials work to a standard of efficiency not usually found in Government Departments, and it is pleasant to record the fact. We reproduce the memorandum almost *in extenso*, as follows :

Situated in the heart of Canada lies a stretch of land between the east and the west, nearly 1,000 miles in width. Its population is small and scattered. Save for mining areas, logging camps, and the thriving grain-shipping towns of Port Arthur and Fort William, it is largely undeveloped. A dividing territory, it is recognised as one of the most important factors in the political and economic life of the Dominion as a whole. On few branches of the country's activities, however, does this area have so potent an effect as on its commerce, and in particular on the distribution of goods; it is, therefore, with a view to a partial explanation of its bearing on British trade in Western Canada that this report is written.

British firms, doing business in Western Canada through resident Canadian agencies, usually employ one or other of the following channels : (*a*) Agents resident in Western Canada. (*b*) Branch offices of Eastern Canadian agents. (*c*) Sub-agents, resident in Western Canada, of Eastern Canadian agents. (*d*) Agents resident in Eastern Canada who may, or may not, pay periodical visits to Western Canada. Many British firms are represented by the types of agents included in groups (*a*) and (*b*). These methods of representation have also been adopted by numerous Canadian and American manufacturers, and undoubtedly have been found to be satisfactory. United Kingdom manufacturers have in some cases not fully appreciated the reality of the division of Canada, and have in consequence appointed agents in the East also to cover the West. This policy is at times resented by the importers.

The methods of doing business in Western Canada suggested by groups (*c*) and (*d*) cannot be said invariably to be satisfactory, although certain British manufacturers have done business successfully in those ways. The appointment of sub-agents by the Eastern representatives is evidence of their appreciation of the fundamental difficulties referred to, and a desire to do their duty by their principals. Sub-agencies, however, are not always popular either with the appointees or with the customers. The former sometimes object to share their commissions and are apt to devote their attention to lines that are more remunerative; the latter like to deal with direct representatives of the manufacturers, and may object to doing business through an Eastern Canadian house with whom they have no first-hand acquaintance.

Representation for Western Canada by firms in class (*d*) is, for many lines, unsatisfactory. For reasons that will be enlarged upon in the following paragraphs, few, if any, such agents visit Western Canada more than once a year, and many never come at all. It is obvious, therefore, that they cannot adequately canvass the trade, and many do not attempt to do so. It is considered most desirable that all customers should be called on several times a year and in the right seasons. It is only fair to say that the Eastern Canadian agents who actually spend the greater part of the year travelling both in the East and West have achieved satisfactory results.

The following is an attempt, by detailing some of the distances that have to be covered, and the expenses that have to be incurred, by an agent in Eastern Canada who visits the Western Provinces, to assist United Kingdom firms to understand and overcome some of the physical difficulties of doing business in this country.

Distance.—On his way West to Winnipeg a Montreal agent does not pass through the populated and industrial section of Ontario, which is situated to the south of the main transcontinental line and requires a separate visit. He therefore has to travel a distance of 1,411 miles before he reaches the first city in the territory he desires to cover, Winnipeg. The distance from Winnipeg to Vancouver, the most westerly city of importance, is 1,474 miles, and there are several cities in between, not always on the direct route, at which he will have to stop. It may therefore be estimated that an agent making such a trip covers, in the course of his journey, almost exactly 6,000 miles. In question of time the direct journey from Montreal to Vancouver takes five nights and four days, so, taking into consideration the number of stops to be made, it is probable that he spends about twelve nights and eight days on the train.

Cost.—The cost of travel in Canada is high and even with due regard to economy is a serious item. The following show the estimated expenses of such an agent, resident in Montreal, on a trip (*a*) as far as Winnipeg, (*b*) to Vancouver, calling at Winnipeg, Regina, Saskatoon, Edmonton and Calgary *en route* :—

(*a*)

Montreal to Winnipeg and return—	dols.
Railway fare (low rate for certain seasons)	72·75
Sleeping accommodation on train	28·10
Meals on train	20·00
Handling baggage and incidentals	5·00
21 days living expenses at Winnipeg	189·00
Sample room, if required	42·00
	356·85

This sum is equivalent at 4.55 dols. to 78*l.* 8*s.* 7*d.*

(*b*)

Montreal to Vancouver, calling at intermediate points and return—	dols.
Railway fare (lowest rate)	133·65
Sleeping accommodation on train	56·30
Meals on train	50·00
Handling baggage and incidentals	18·00
35 days living expenses in cities	315·00
Sample rooms, if required (say)	60·00
	632·95

This sum is equivalent at 4·55 dols. to 140*l.*

In order to pay his out-of-pocket expenses, earn a fair sum for his services, and pay a proportion of the maintenance of his office in Montreal, an agent making a trip (*a*) would require to sell goods at least to a value of 15,000 dols, reckoning his commission at 5 per cent., or to a value of 30,000 dols. if his commission was 2½ per cent., and if making trip (*b*) would require to sell goods at least to a value of 24,000 dols. at 5 per cent. commission, or 48,000 dols. at 2½ per cent. commission. The value of an agent's services for the purpose of these examples has been placed at 350 dols. per month. An allowance of 9.00 dols. per day for hotel, room and meals has been included. No allowance has been made for the entertainment of customers, which is frequently desirable.

When the above facts and figures are borne in mind, and it is remembered that other extensive areas in Canada—Ontario, Quebec and the Maritime Provinces—have also to be covered during the course of the year, it is hardly surprising that many agents cannot afford to visit Western Canada at all, and that the majority of those who do come do not make the trip more than once or twice a year.

British manufacturers represented at present in Eastern Canada for the whole of the Dominion by agents included in group (*c*) and (*d*) may desire to consider and discuss with their agents whether all the available business in the West is being secured and whether it is not desirable to have resident representation in Western Canada.

It has already been suggested that the best method of doing business in Western Canada is by resident agents or by branch offices of Eastern Canadian agents. While it is difficult to generalise, it is believed that of these two the former is, generally speaking, the more satisfactory method. Experience shows that there is a tendency among the Western buyers, when all other things are equal, to place their orders with local agents of class (*a*), and as there are a number of suitable firms, particularly in Winnipeg and Vancouver, this is a tendency of which advantage might well be taken. It should be borne in mind that for such representation, whether in Winnipeg or Vancouver, or both, by agents on commission, there would be no additional expense, and it is probable that any additional trouble would be more than repaid by the increased business that would result.

British firms apparently have not been able in many instances to cater for Western Canadian trade as have their American competitors. Agents of the latter, resident in Chicago, Minneapolis and Seattle, cities far nearer to Winnipeg and Vancouver than Montreal or Toronto, cover the territory with the greatest care, and are, it is believed, amply repaid for their trouble. It is thought, however, that much of their present business could be secured by British manufacturers if they canvassed the market in the same way and had their agents resident in the country. There is little question that the local importers, whose present complaint is that they are not sufficiently catered for by Britain, would welcome the opportunity of buying from a larger selection of British goods, and it is therefore felt that, at a time when all orders are needed, a real effort should be made to secure the business that can most certainly be had if properly sought.

It is therefore suggested that British manufacturers with representation only in Eastern Canada should review their business with the Dominion in the light of the above statements, and consider whether, in their opinion, they are receiving all the orders that should be obtainable from the Western Provinces. If they are not, an investigation and a consultation with their present agents might prove profitable. His Majesty's Trade Commissioner for Western Canada at Vancouver and his deputy at Winnipeg are always prepared to assist by advising on this subject or by suggesting the names of suitable agents, and will welcome enquiries from manufacturers interested.

They may be addressed as below :—

His Majesty's Trade Commissioner for Western Canada, 210, Winch Building, Vancouver.

The Officer in Charge,
Office of His Majesty's Trade Commissioner,
703, Union Bank Buildings, Winnipeg.

ACOUSTICAL PROBLEMS.

MATHEMATICAL treatment of sound propagation problems, was said by Major M. S. Tucker, D.Sc., Director of Sound Ranging in the Army, in two Tyndall lectures, delivered at the Royal Institution during the past fortnight, to be relatively easy as long as the dimensions of a laboratory, the obstacles in it and the instruments used, were large by comparison with the wave-length. When the quantities were of fairly the same order, as in the acoustical problems of our ordinary rooms, of the trumpet as a collector and transmitter of sound, and of the speaking tube, solution was possible only by a judicious blending of theory and experiment.

The sound from a loud speaker indoors varied, the lecturer said, if the listener moved his head, showing that the acoustic field was anything but uniform, and a vibrating galvanometer, in circuit with a microphone and a valve amplifier, might violently be disturbed when the microphone was moved in the room to a different spot. By such means it had been proved that the reflection from materials of different sound-absorbing power, glass, wood, felt, &c., varied with the wave-length of the source, and that the sound "images" were multiple, because most sounds were not pure notes, and because the swelling and fading of the sound in the several images depended upon the distance of the reflector. To reduce these reverberations or echoes—their total suppression was not desirable—we made the walls very absorbent and used in experiments electric oscillators giving pure notes as sound sources. The ordinary siren, a rotating disc, provided with circular holes, did not produce pure notes; but it gave harmonic waves, as E. A. Milne and R. H. Fowler had shown, when the holes were made lenticular with wavy outlines in sine relation to the rotation of the disc. In investigating sound-absorbing powers, Major Tucker placed a block of material in a cubical box provided with a window, the partial closing of which raised the resonance pitch of the box. When the block material was brass, the window had to be closed to bring the box up to tune again; when the block was felt (a good absorber), the window had to be opened to restore tuning; the reduction of volume was the same in the two cases, but the felt had the effect of making the box larger and of exerting a "drag" on the air vibrations.

Another method for these absorption studies was to observe the nodes and anti-nodes obtained at a single reflection from the absorbent surface, the intensity maxima and minima being less pronounced with good absorbers. A convenient detector for vibrations in pipes &c., was a hot-wire grid, an electrically-heated fine platinum wire; the wire was connected with an amplifier and a vibration galvanometer to measure the periodic resistance changes due to the cooling air currents, and with a Wheatstone bridge to measure

GENERATOR FOR AUTOMATIC TELEPHONE EXCHANGES.

CONSTRUCTED BY MESSRS. STUART TURNER, LIMITED, HENLEY-ON-THAMES.

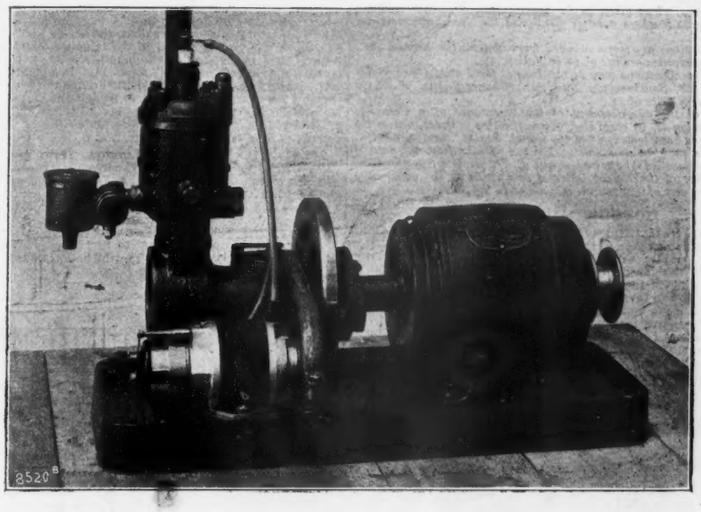


FIG. 1.

Fig. 2.

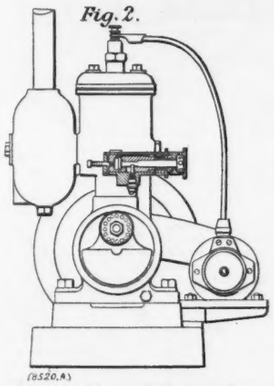
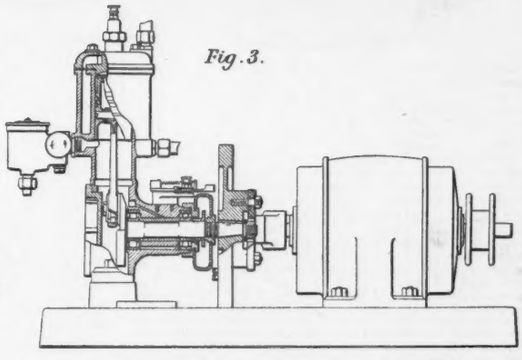


Fig. 3.



the steady resistance changes. By combining a Helmholtz resonator (a bottle whose resonance pitch depends upon its volume and the dimensions of its neck) with a box into which the neck (with a wire grid in the neck) projected, Major Tucker had obtained a very sensitive instrument for studying, for instance, the combination of the diaphragm and trumpet of a loud speaker.

The outdoor laboratory, Major Tucker explained in his second lecture, was preferable to the indoor laboratory for large-scale experiments, because out of doors there was little trouble due to reflection and stationary waves, apart from reflection from the ground, and because powerful sources of sound, foghorns on the ground and aeroplanes up in the air, could be used. There were, however, local temperature differences, especially in daytime and in winter and spring, convection currents, and the wind. In still air the wave front (of equal sound intensity) from a source on the ground was spherical (circular in section). A light wind distorted the wave front (the circumference becoming wavy). Strong winds and local heating would lift the wave front up from the ground and break it up, so that zones of silence were formed near the ground and again higher up. As the wind was rarely steady, and mostly veered round at higher altitudes, these problems became exceedingly complex, especially also for sound propagation from aeroplanes. The receiving microphones could, however, be protected against local eddies, with winds up to 10 ft. per second at any rate, by screens or bonnets of muslin. Major Tucker showed that he could extinguish a candle by blowing through a slab of felting, but not by blowing through a "loofah" sponge. That the recent explosion at La Courtine had not been heard at all at Biggin Hill, Hythe, and Cambridge, might simply be due to the great distance, 400 miles.

In the atmosphere, Major Tucker proceeded, sound was reflected, refracted and absorbed by visible clouds and fog banks, and by the invisible clouds of vortices or local temperature variations. While in the fog, the sound would come through well; but when it had to pass through the fringe of the cloud, it would be greatly absorbed. That had been established by exchanges of signals between the shore and the Goodwin Lightships. The microphones used for listening were of the double-resonator type, both parts of the instrument being tuned to 180 vibrations; the combination would only respond to frequencies ranging from 170 to 190. The directive sound apparatus of Major Tucker depended either on the observation of maximum intensity, or upon the use of the two ears. Wooden cone trumpets and microphones served as receivers, and a concave mirror, made of concrete, 20 ft. in diameter, served as reflector. In order to take measurements in different planes, two pairs of trumpets were mounted, one on a horizontal and the other on a vertical axis, and the whole trumpet arm was pivoted at the centre of curvature of the mirror. The directiveness so determined was good as long as the wave front was smooth. With distorted wave-fronts directional tests were very difficult. It was further noteworthy, and rather fortunate in a way, that the air refused to transmit waves of big amplitude, and that the piling up of horse-power in noise-producing machines failed to give adequate effect.

SMALL GENERATOR SET FOR AUTOMATIC TELEPHONE EXCHANGES.

A 120-WATT electric generating plant specially designed for the General Post Office to meet the power requirements in small automatic telephone exchanges is shown in the illustrations, Figs. 1 to 3, above. The conditions under which engines have to operate in this service impose many restrictions on the designer, who has not merely to devise a small reliable power unit, but must ensure that it runs silently, to avoid interference with telephone speech, and that after starting by an unskilled workman it may be left to operate without supervision. The fact that this engine has been approved and accepted for use by the Post Office is a clear indication that the exacting conditions are not insurmountable. The engine was designed and constructed by Messrs. Stuart Turner, Limited, of Market-place, Henley-on-Thames, and is shown on their stand in the Palace of Engineering at the British Empire Exhibition. A general view of the complete equipment is provided in Fig. 1, while the details of construction are shown in Figs. 2 and 3.

The engine has a cylinder bore of 1¾ in., while the stroke is 2 in. The two-stroke cycle is used, and consequently there are no movable valves, tappets or valve gears. The cylinder head is detachable, but is so shaped as to permit the entry of cooling water from the jackets of the barrel. Careful consideration has been given to the reduction of friction, not only to improve the efficiency of the engine, but also to reduce the wear and tear and thus remove the necessity for frequent overhauls. A bronze bush is used for the small end of the connecting rod, but the big end is provided with a roller type of bearing. The simplicity of the arrangement at the crank pin is evident from Fig. 3, and the provision of the balance weight on the crank, which is also there shown, makes for smooth running. A roller bearing is fitted to the crankshaft near the overhung crank. This, with a ball race at the other end, gives ample support to the shaft and ensures that the engine, though small, will stand up to hard and continuous service.

From the flywheel the drive is taken through a flexible coupling to the dynamo. A governor of the trip type is provided, which cuts out the magneto should the speed, through any cause, become excessive. The engine may be fitted for use on petrol or coal gas. When petrol is used, the lubricating oil is mixed with the fuel and reaches the interior of the cylinder with it. A drip feed lubricator is fitted, however, if gas is the fuel. The generator is shunt wound, normally to give a pressure of 16 volts. The set is used for other purposes than that of the automatic telephone systems. It finds useful service for small lighting installations and for charging batteries. A unit of the same type but of 500-watts capacity is also manufactured by Messrs. Stuart Turner, Limited, and is used on the exhibition stand to supply current for lighting purposes and for the operation of a number of motor-driven models.

PHYSICAL SOCIETY OF LONDON.

AT the meeting held on May 23, 1924, at the Imperial College of Science, with Mr. F. E. Smith, F.R.S., in the chair, a paper on "*The Magnetism of Annealed Carbon Steels*," by Professor S. W. J. Smith, F.R.S., A. A. Dee, and W. V. Mayneard, was read by Professor Smith. This was a sequel to one by Professor S. W. J. Smith and Mr. J. Guild on the "*Self-Demagnetisation of Annealed Steel Rods*," in which it was shown that the residual moment of a magnetised rod of annealed steel (of particular dimensions) did not diminish continuously towards zero as the temperature was raised, but changed sign at about 180 deg., reached a maximum negative value at about 220 deg., and subsequently slowly fell until the temperature at which steel ceased to be ferromagnetic was attained.

Experimental evidence was adduced to show that the reversal was primarily due to the laminated structure of the iron-iron carbide "eutectoid" which the steel contains. It was shown that the reversal disappeared when this structure was destroyed, and an explanation of the fact that the effect was most pronounced in a steel containing the eutectoid percentage of carbon was given. Measurements had been made to find how the intensity of the residual moment at 220 deg. depends upon (1) the dimension-ratio of the bar; (2) the intensity of the field by which it was magnetised. The results were described and an interpretation was given. It was suggested that measurements of the kind described could be employed to obtain rapidly and in a simple manner useful information concerning particular samples of steel.

In the discussion Mr. J. Guild said that it came as a pleasant surprise to him to find that the paper dealt with an extension of the work carried out some years ago by Professor Smith and himself, and he was very glad that their original explanation of the facts had been vindicated so clearly. This explanation when first put forward had been rather criticised, particularly by Williams, who proposed an alternative theory. A number of phenomena could be quoted in support of the original view, but instead of detailing these he would refer to some further work which had not been published. Williams had tried to repeat some of the experiments with a large thick rod, and had found that the polarity-reversal effect occurred if the magnetising field was broken suddenly but not if the specimen was gradually withdrawn from the field. He based a theory on this fact and wished to explain the original experiments by means of it, but as a matter of fact the conditions assumed by him did not obtain in the experiments in question. He had tried to repeat Williams' results with rods of various sizes, and found that their character was reversed when small rods

were used. He had been able to trace the effect of the dimensions of the specimens on the results obtained, but had been obliged by the pressure of other work to abandon the investigations. The fresh light on the matter contained in the paper now before the meeting should make it possible to explain this effect in polarity reversal of a sudden change of field.

A paper was next read on "*Some Thermo-Magnetic-Properties of Nearly Pure Iron*," Part I, by W. V. Mayneard; Part II by A. A. Dee.

From Part I it would appear, from various investigations published in recent years, that, when the variation with temperature of some particular physical property of iron was studied, discontinuities in the rate of variation occurred at certain more or less sharply defined temperatures. The object of the experiments described was to find whether any corresponding changes in the magnetic properties of iron could be traced. The experiments were made by the ballistic method upon Armco iron. Observations of the induction were made practically continuously during heating and cooling. The range chiefly studied extended from 15 deg. C. to about 350 deg. C.

It was found that the most noticeable variations occurred in weak fields (of the order 0·1 C.G.S.) and that they depend in a fairly definite way upon the previous thermal treatment of the material. For instance, if the iron had been previously heated to 700 deg. C., the most noticeable features of the induction-temperature curve was a rapid rise to 50 deg., followed by a slow rise to about 230 deg. C. This was followed by a fall which extended to about 300 deg. C., after which the apparent permeability rose again. The effects of other heat treatments such as slow cooling from 500 deg., quenching from 820 deg. and 940 deg. respectively, were described. The effects of strain were also examined and it was found that strained iron showed none of the effects until it was annealed. The variation of the magnetic properties during the course of the annealing process could be observed. The correspondence between the magnetic changes and those of electrical, mechanical and other properties of iron was discussed.

In Part II, by A. A. Dee, it was pointed out that when rods of annealed iron are magnetised at air temperature and heated, the residual intensity curves show abnormalities over the range 100 deg. C. to 130 deg. C., and at 230 deg. C. When the rods were magnetised at about 300 deg. C. and cooled the residual intensity fell with diminishing temperature until about 90 deg. C. and then rose slightly. In addition there was an abnormality over the range 130 deg. C. to 90 deg. C. If the specimen had just previously been cooled from about 240 deg. C. then, in certain circumstances, the first magnetic test over the range up to about 240 deg. C. gave results which differed from those of subsequent tests. Cold drawn iron wires showed no anomalies in their behaviour over the range up to 300 deg. C.

In the discussion Dr. E. P. Harrison suggested that it would be interesting to repeat the experiments with iron laid down electrolytically in a magnetic field, for instance, on a platinum wire. The structure of such iron would be very simple and regular.

Dr. F. L. Hopwood said he understood that platinum became alloyed with iron at a temperature of about 300 deg. This fact would constitute an objection to the proposal of the previous speaker.

Mr. F. E. Smith said that he would like to see the effect of lapse of time on the magnetisation of the specimens, the temperature being kept constant. In making permanent magnets out of tungsten steel it was the practice to apply, after magnetisation, a small demagnetising field in order to confer permanency. Even after this treatment the moment of the magnet decreased by several per cent. in five minutes, and continued to decrease to some extent for weeks. The authors' curves were very sensitive, so that unless observations were taken with great regularity the discontinuities might be due to the time effect. It would be well to try the effect of keeping the temperature constant for some time in the neighbourhood of the discontinuities, preferably using purer samples of iron.

A paper on "*The Atomic Structure of Two Intermetallic Compounds*," by Mr. E. A. Owen and Mr. G. D. Preston, was also read by Mr. Preston, after which a demonstration was given by Professor A. O. Rankine of "*An Anomaly in Frictional Electricity*," dealing with the change of sign of charges acquired by an ebonite rod struck against a piece of flannel.

YORKSHIRE STRUCTURAL ENGINEERS.—At a meeting held in the Town Hall, Halifax, on Saturday, the 14th inst., it was decided to found a Yorkshire Branch of the Institution of Structural Engineers. The meeting was addressed by the President of the Institution, Major James Petrie, who explained the aims and activities of the Institution and the benefits accruing to members of a branch. The acting local secretary is Mr. D. Lloyd Jones, Halifax.

"ENGINEERING" ILLUSTRATED PATENT RECORD.

SELECTED ABSTRACTS OF RECENT PUBLISHED SPECIFICATIONS UNDER THE ACTS OF 1907 AND 1919.

The number of views given in the Specification Drawings is stated in each case; where none is mentioned the Specification is not illustrated.

Where inventions are communicated from abroad, the Names, &c., of the communicators are given in italics.

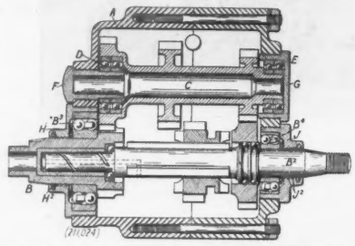
Copies of Specifications may be obtained at the Patent Office, Sales Branch, 25, Southampton Buildings, Chancery-lane, W.C., at the uniform price of 1s.

The date of the advertisement of the acceptance of a Complete Specification is, in each case, given after the abstract, unless the Patent has been sealed, when the word "Sealed" is appended.

Any person may, at any time within two months from the date of the advertisement of the acceptance of a Complete Specification, give notice at the Patent Office of opposition to the grant of a Patent on any of the grounds mentioned in the Acts.

MOTOR ROAD VEHICLES.

211,024. S. L. Bailey, Bristol. Change Speed Gear Mechanism. (2 *Figs.*) March 17, 1923.—The invention relates to change speed gear mechanism preferably for use on motor cycles, and has for object to provide a simple construction of gear box wherein the shaft bearings will be strongly supported. According to the invention, there are screwed into the box hard metal housings or supports for the ball bearings of all the shafts and all these housings act as closures to prevent oil leakage. The gear box A is divided transversely to the axes of the driving and driven shafts B and B2, coaxially mounted, and a lay-shaft C in permanent gear with the driving shaft. The lay-shaft C



is mounted upon ball races at D and E, which are supported by housings in the forms of caps F and G, which completely prevent any oil leakage. The cap G surrounds the bearings and is engaged by the outer race, but the cap F engages the interior of the bearings supporting the inner race. With the driving and driven shafts B and B2 the bearings B3 and B4 are supported in housings H and J, which are extended along the shafts B and B2 and carry devices for preventing leakage of oil, such as a stuffing box shown at H2, or helical oil return grooves J2, or both may be used. The caps house the ball bearings in the gear box walls, and also prevent oil leakage. (*Sealed.*)

210,961. C. E. Batcock, Richmond. Variable Speed Gears. (4 *Figs.*) October 9, 1923.—The invention relates to gears of the kind comprising a driving shaft and a driven shaft, eccentrics mounted on the driving shaft, straps on the eccentrics and one-way clutch connections between the straps and the driven shaft. The object of the invention is to provide means for varying the throw of the eccentrics in a gear of the kind described. Within a casing 1 is mounted a hollow driving shaft 2 having three solid eccentric bosses on which are mounted three variable throw eccentrics 3, 4, 5, arranged at 120 degrees. Each eccentric sheave 6 carries two eccentric straps 7, 8 having short connecting rods 9, 10, respectively, the ends of which are

Fig. 1.

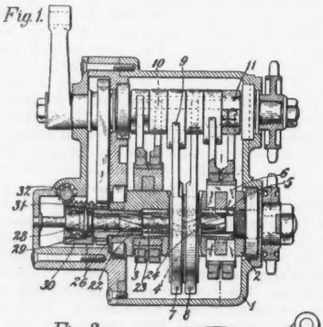
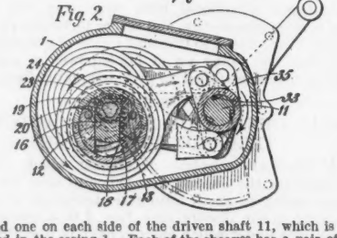


Fig. 2.



disposed one on each side of the driven shaft 11, which is also mounted in the casing 1. Each of the sheaves has a pair of flat parallel surfaces 12, 13, which engage similar flat parallel surfaces on the eccentric bosses 16 of the shaft 2. Each sheave has a toothed rack 17 projecting from one of the flat surfaces 12 or 13 into the interior of the shaft 2, and moving in a groove 18 in the eccentric boss 16. Within the hollow shaft 2 is arranged a sleeve 19 having longitudinal teeth 20, which engage with the racks 17. Within the sleeve 19 is arranged a spindle 23 having helical splines 24 which engage internal splines in the sleeve 19. At an intermediate point of its length the spindle 23 has helical splines 26 of opposite hand to the splines 24 which engage with internal splines in a member 22. Towards its end the spindle 23 is shouldered at 28, which shoulder forms ball races 29 for a ball bearing within the cage 30. The cage on the outside at its upper part is provided with a toothed rack 31 which engages a pinion 32 operated by a control lever. The driven shaft 11 has a number of longitudinal recesses 33 cut in its surface in which are disposed rollers. Each connecting rod 9, 10 is connected to one end of a link 35 which, at its opposite end, is of circular shape and is mounted on the driven shaft 11. These links together with the rollers and the depressions 33 in the shaft 11 constitute one-way clutches, the link 35 on being moved over in one direction gripping the roller and the shaft and thus turning it. When the link is moved in the opposite direction the roller returns to a lower part of the depression 33; consequently no motion is transmitted to the shaft 11. In operation, the drive is transmitted from the driving shaft through the eccentrics 3, 4, 5, the sheaves 6, connecting rods 9, 10 and the clutch mechanism 33 and 35 to the driven shaft 11. By moving the spindle 23 longitudinally by means of the pinion 32 the throw of the eccentrics is altered, whereby the gear ratio is varied. (*Sealed.*)

210,879. H. E. Spencer, London. Transport Vehicles. (9 *Figs.*) November 10, 1922.—The invention relates to transport vehicles of the type having means for dividing up the load of the vehicle into conveniently handled units which can be readily mounted on and dismounted from the vehicle as desired. According to the primary feature of the invention, there is provided a transport vehicle having (*a*) its upper surface, which is to be loaded without having to be tilted, provided with one or more sets of guide-tracks 12 which lie longitudinally from front to rear of the vehicle and are suitable for receiving and

Fig. 1.

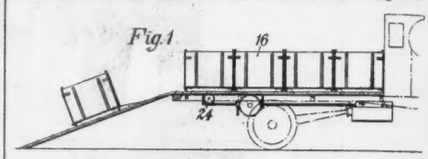
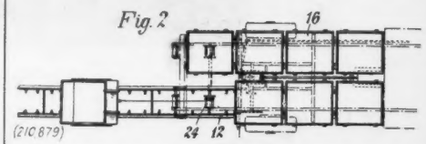


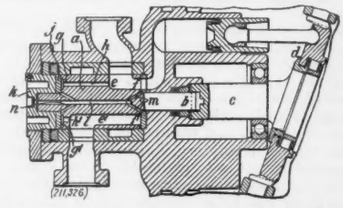
Fig. 2.



guiding into and out of position along the vehicle surface a number of trucks 16, which can be separately mounted on and discharged from the tracks and divide up the load of the vehicle into conveniently handled units, and having (*b*) winch gear 24 and rope-guiding mechanism for manipulating the trucks on to and from the guide-tracks 12. According to another feature of the invention, the guide-tracks comprise each a series of rollers and are intended to co-operate with skids upon the trucks. According to a further feature of the invention, rails constitute the guide-tracks and are intended to co-operate with wheels upon the trucks. (*Sealed.*)

PUMPS.

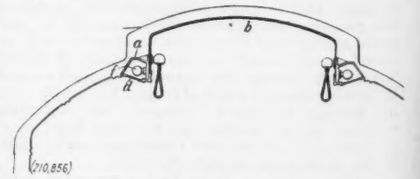
211,326. Sir W. G. Armstrong, Whitworth and Company, Limited, Newcastle-on-Tyne, H. W. Lee, Newcastle-on-Tyne, and F. P. Fee, Newcastle-on-Tyne. Rotary Valves. (1 *Fig.*) January 30, 1923.—The invention relates to rotary valves for pumps in which the working fluid is supplied to the valve in a direction transverse to its axis and passes through ports at the end of the valve to ports of the pump cylinders. According to the invention, grooves are made in the end of the valve remote from the ports, which grooves may be of similar shape and of area less or greater than or equal to that of the valve ports, as desired. The grooves are connected to the valve



ports by one or more holes extending through the valve, and a washer may be inserted between the end of the valve and the end of the casing. *a* is a rotary cylindrical valve connected by a coupling *b* to the shaft *c* of a swash plate *d*, and the working fluid passes through passages *e*, *e*1 controlled by valve ports *f*, *f*1 at the end of the valve. Grooves *g*, *g*1 are made in the other end of the valve, the grooves being connected to the valve ports *f*, *f*1 by holes *h*, *h*1. A washer *j* is inserted between the end of the valve *a* and the end of its casing *k*. A hole *l*, having bifurcated ends *m*, *m*, extends from one end of the valve to the other and other holes *n*, *n* extend from the hole *l* towards the washer *j*. (*Sealed.*)

RAILWAYS AND TRAMWAYS.

210,856. Cammell, Laird and Co., Limited, Sheffield, and A. S. Bailey, Sheffield. Interior Lighting of Vehicles. (3 *Figs.*) November 7, 1922.—The invention relates to vehicles the interiors of which are to be lighted. The illumination is effected by means of electric lamps *f*, each arranged within a casing *a* in the roof *b* of the vehicle and above a glazed member *d*



at the roof of the vehicle, the position of the glazed member being selected to suit the manner of light distribution desired. The glazed member may serve wholly or partly to close the casing *a*, which is of trough or box-like shape extending longitudinally along the roof. Such trough or box-like casing may form a stiffening member in the construction of the vehicle. (*Sealed.*)